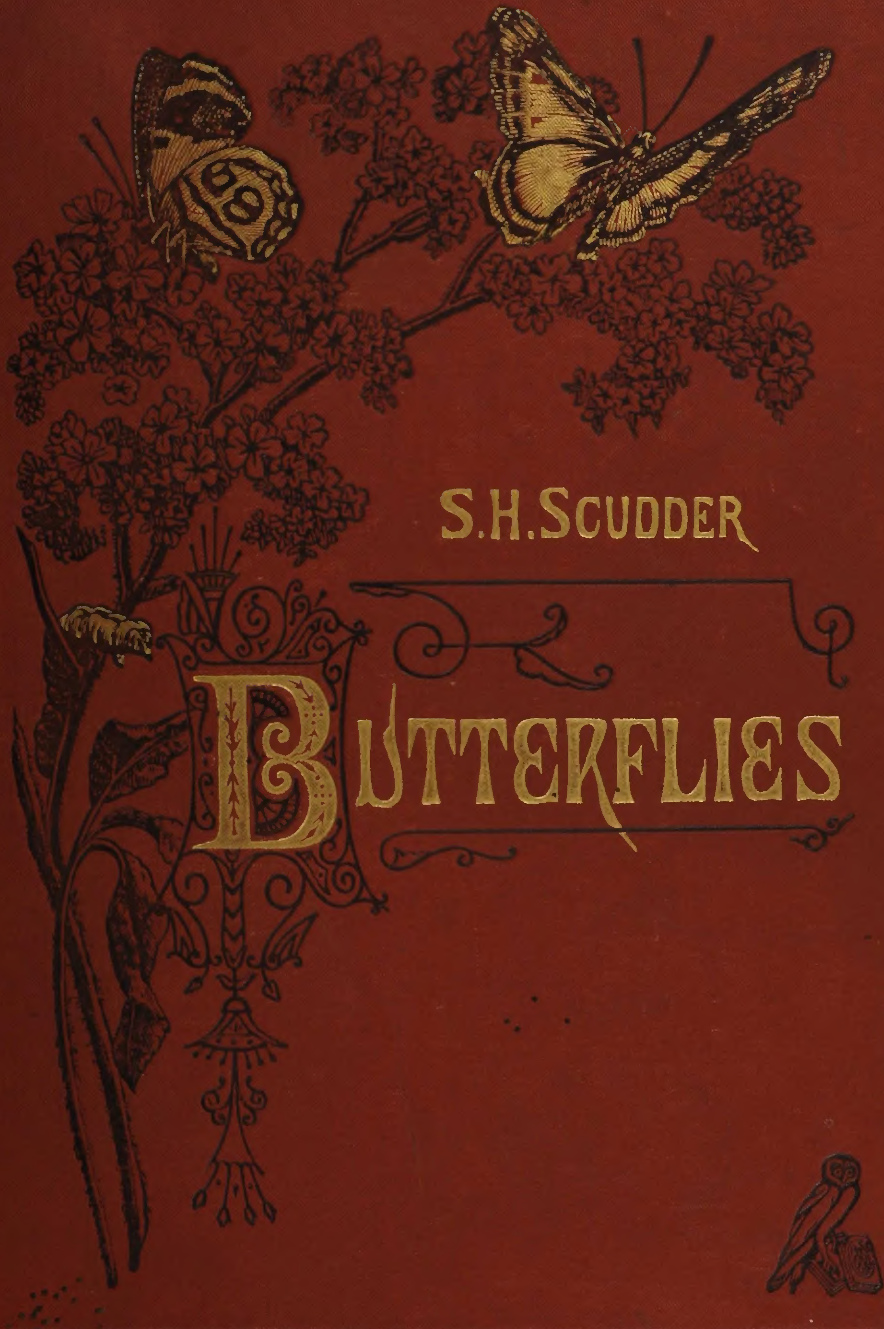
S.H.SCUDDER
BUTTERFLIES

125-

Caroline E. Heustis

1881.

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BUTTERFLIES.

BUTTERFLIES

THEIR

STRUCTURE, CHANGES, AND LIFE-HISTORIES

WITH

SPECIAL REFERENCE TO AMERICAN FORMS

BEING AN APPLICATION OF THE "DOCTRINE OF DESCENT" TO THE STUDY OF BUTTERFLIES. WITH AN APPENDIX OF

PRACTICAL INSTRUCTIONS

BY

SAMUEL H. SCUDDER

NEW YORK
HENRY HOLT AND COMPANY
1881

PREFATORY NOTE.

A box of common butterflies hanging on the wall of a fellow-student's room in college first introduced the author to the enjoyments of a naturalist's life. He ventures to hope that the following pages, in which he gathers the observations and reflections of many years—the outcome of his friend's collection—may induce many another to enter this interesting and fruitful field, where Nature is ever new, and many a problem still remains unsolved.

The author is indebted to Hon. Charles L. Flint for the liberal permission to take electrotypes from the original wood-cuts illustrating the butterflies in Harris' Treatise on Insects Injurious to Vegetation ; these woodcuts, drawn by Sonrel and engraved by Marsh, are masterpieces of xylographic art and illustrate the best work of American engravers. The Boston Society of Natural History, Dr. A. S. Packard, Jr., and Messrs. W. H. Edwards and William Saunders have also permitted the use of a few cuts in their possession. A considerable number have been procured from Mr. C. V. Riley, and a few from the publishers of the *American Naturalist* through Mr. Edward Burgess, whose paper on the action of the butterfly's trunk they illustrate. Mr. Burgess has also kindly drawn a couple of anatomical figures. All of these are properly credited. The others are from drawings in the author's possession, and, with the exception of half a dozen woodcuts engraved by the Messrs. Andrews, were prepared for photographic reproduction by Mr. J. S. Kingsley.

TABLE OF CONTENTS.

"The study of butterflies—creatures selected as the types of airiness and frivolity—instead of being despised, will some day be valued as one of the most important branches of biological science."

BATES, *Naturalist on Amazons.*

INTRODUCTION.

THIS little work treats of butterflies—the higher families of the great order Lepidoptera, or scaly-winged insects. They do not form a scientifically natural group, since their sole distinction from other Lepidoptera lies in the character of the antennae ; and this itself is a point of great variability ; but for convenience' sake, and with this reservation, we may use the term butterfly as a popular expression.

The foundation of our study will be laid upon an examination of the earlier stages of the butterfly. Ruskin has declared * that the prevalent "instinct for the study of . . . the lower forms of undeveloped creatures . . . is the precise counterpart of the forms of idolatry (expressed in the worship of unclean beasts), which were in great part the cause of final corruption in ancient mythology and morals." Yet not only shall we find in these lower stages forms of exquisite beauty, little known even to the world of

* Fors Clavigera, Letter 53, pp. 138, 139, note.

naturalists, but the closer we examine their structure and development, the more abundant proofs shall we find of harmonious adaptations to their surroundings; and just as their organization ever foretokens a more perfect form, so shall we be led to an increasing apprehension of the consummate skill by which is produced and upheld that wonderful co-ordination of structure, form, development, and relation to the outside world, which the complete study of any creature exhibits. It is the growth rather than the perfection of any organism which is of supreme interest; and not until we penetrate into the deepest mysteries of the earliest and most humble existence of organic forms, can we have any conception of the marvels of life and growth, or apprehend the workings of the Creator.

When we study the perfect insect, we shall trace the mode by which its new organs, external and internal, have been developed from strangely different parts in the immature stages. Then we shall take the greatest pains to get at the creature's habits of life; "know all its ingenuities, humors, delights, and intellectual powers; that is to say, what art it has, and what affection; and how these are prepared for its external form;" * we shall watch the procession of the

* Ruskin, "The Eagle's Nest," p. 154.

seasons, and follow the varied histories of our friends at different epochs of the year; inspect their habitations, and see what preparation they make for the long repose of winter. We shall devote much space to their coloring,—not to dilate upon its exquisite delicacy or wonderful play, but to study the curious laws by which it varies in the same species at different seasons, or in different latitudes; by which each sex, after its own fashion, vies with the other in adornment; and by which new forms are apparently originating under our very eyes. Finally, we shall treat of the ancestry, present affinities, and distribution of these insects; endeavor to discover what the primeval butterfly was like, what sort of an egg it laid, what the cycle of its changes, and how we should arrange the living forms; all these topics we shall illustrate by almost exclusive reference to the butterflies of America, and especially of our own New England, and close by showing how New England was colonized with its present butterfly inhabitants.

CHAPTER I.

THE EGG.

Like all other lepidopterous insects, the butterfly is well known to undergo peculiar and, to outward appearance, very sudden transformations. The butterfly with maternal instinct lays its eggs upon a certain food-plant; this egg produces a worm-like animal called a caterpillar, which feeds voraciously upon the plant, casts its skin several times during its growth, and at the last moulting emerges as a pupa or chrysalis; at this period the insect appears in swaddling-clothes, all its appendages neatly encased upon its breast, and itself almost completely helpless and motionless; to ordinary view as different as possible from the aërial creature, with variegated tremulous wings, we see shortly after, sipping honey from an open flower, or dancing merrily in the sunlight. Changes similar to these are now known to occur throughout no inconsiderable portion of the animal kingdom, but they are most familiar to the popular mind, and were first known to the ancients in the insect tribes, and particularly in the butterflies.

Our first chapters will deal with the earlier stages of the butterfly: the egg, the caterpillar, and the chrysalis.

The eggs laid by these fairy-like creatures are composed externally of a thin elastic pellicle; they are no larger than a pin's head; indeed I know of only one whose diameter is a twentieth of an inch, or a little more than a millimetre. Yet when examined under a lens we may look far before discovering objects more graceful in form or delicate in marking. Their vaulted summits might give useful hints to the architect; indeed, chancing to study some of our New England forms during a winter spent in Egypt, I was greatly struck by their singular resemblance to the traceried domes of the Cairo mosques [Fig. 1]. The extreme summit is always covered by a little rosette of cells of the most exquisite delicacy, often requiring some of the higher powers of the microscope to discern, but arranged in such definite patterns, that, in looking at them, we seem to be

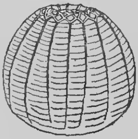


Fig. 1.—Egg of Thorybes Pylades, × 28.

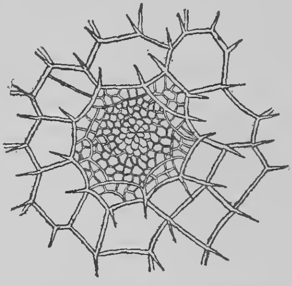


Fig. 2.—Micropyle of egg of Basilarchia Archippus, × 100.

peering through the circular rose-window of a miniature Gothic cathedral [Figs. 2–5]. The cells

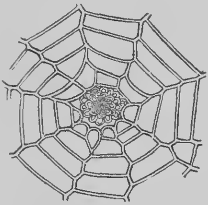


Fig. 3.—Micropyle of egg of Brenthis Myrina, × 40.

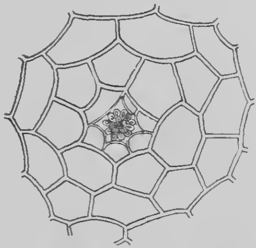


Fig. 4.—Micropyle of egg of Heodes Hypophlaeas, × 100.

which form the interior of this rosette are the points at which microscopic pores or canals lead into the interior of the egg, and through which it is fertilized.

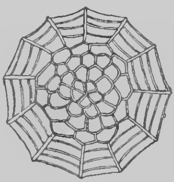


Fig. 5.—Micropyle of egg of Eurymus Philodice, × 60.

The eggs are of every variety of shape; but in general they are flattened on the surface of rest and spherical [Fig. 6], hemispherical [Figs. 7, 8], or sugar-loaf-shaped above [Figs. 9, 10; see also Fig. 17]; in one group they are spindle-shaped [Fig. 11], and in another they have the form of a sea-urchin [Fig. 12]. Some of them,

Fig. 6.—Egg of Jasoniades Glaucus, × 5.

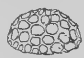


Fig. 7.—Egg of Heodes Hypophlaeas, × 16.

Fig. 8.—Egg of Atrytone Zabulon, × 12.

notably in the lower groups, are almost smooth, but under the microscope some fret-work of cells may be discerned upon the walls of all. Others again, and they form a large proportion, are buttressed upon the sides with upright ribs, which may be seen by the naked eye; sometimes these ribs are coarse and irregular, running in zigzag lines from base to summit, and rendering the egg scarcely distinguishable from those with the coarser network of cells; in others, however, and these are generally confined to the higher types [Fig. 13], the ribs are excessively compressed, mere films, placed edgewise to the body of the egg, glistening in the sunshine like dew-drops, and increasing in size to the summit, where they often form a sort of crown. In still others the ribs thicken and broaden above, so that the summit looks as if covered with little hillocks [Fig. 14]; or the ribs may die out before

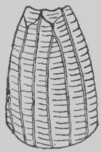


Fig. 9.—Egg of Brenthis Myrina, × 24.

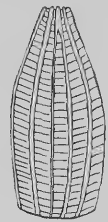


Fig. 10.—Egg of Pieris oleracea, × 27.

Fig. 11.—Egg of Eurymus Philodice, × 10.

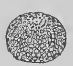


Fig. 12.—Egg of Chrysophanus Thoe, × 11.

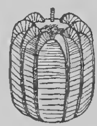


Fig. 13.—Egg of Vanessa Atalanta, × 20.

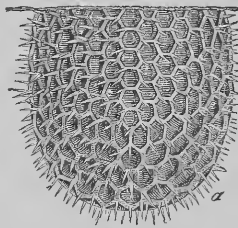
reaching the base, and above may terminate at the edge of a saucer-like depression, which forms the cap of the egg, as is the case in the Baltimore (Euphydryas Phaeton) [Fig. 15]; but everywhere, with more or less distinctness, between these buttressing ribs, the surface of the egg is broken into quadrangular cells [see Figs. 9, 10, etc.] by delicate cross-ridges, which often increase in stoutness toward the main ribs, and in their turn buttress them. In the echinoid eggs [see Fig. 12] the surface is never ribbed, but covered with a heavy net-work of deep pits, whose bounding walls are rather coarse and rough. In these eggs, too, the rosette of microscopic cells at the summit is situated at the bottom of a very deep and narrow well, where they can with difficulty be seen. Other shells, as in the globular eggs of the purples (Basilarchia), have the same style of pitting; but the cell-walls, though high, are thin, and at every angle emit a little filament, which gives the egg a bristling appearance [Fig. 16]. In some, the ribs and the cross-ridges are so numerous and of so similar a prominence [Figs. 17, 18] as almost to make them resemble the network of pits on less regular eggs; while in others, like the nearly globular eggs of our em-

Fig. 14.—Egg of Pholisora Catullus, × 15.

Fig. 15.—Egg of Euphydryas Phaeton, × 10.

peror butterflies (Chloripe) [see Figs 183, 185], where the longitudinal ribs and the cross-

Fig. 16.—Egg of Basilarchia Archippus, *a*, × 30; *b*, natural size, on under surface of leaf (Riley).



ridges are almost equally close, no such appearance is produced, on account of the proportionally greater prominence of the longitudinal ribs.

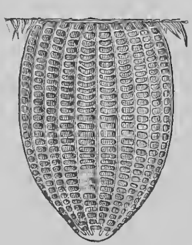


Fig. 17.—Egg of Danais Plexippus, × 30 (Riley).

Most of these egg-shells are opaque; or, if transparent, are so covered with raised ridges in the form of ribs or cell-walls as to render an examination of the eggs very difficult, though not impossible to the determined naturalist. Still, whether from this difficulty or by mere chance, very little is actually known of the changes undergone by the yolk and the surrounding parts, and of the for-

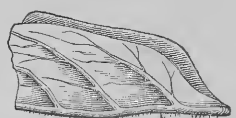


Fig. 18.—Egg of Danais Plexippus, nat. size, on under surface of leaf (Riley).

mation of the embryonic caterpillar; we merely know that nothing essentially different transpires from what occurs in other insects; the yolk-mass first breaks up into an infinite number of cells, and then those lying next the surface enlarge, and form what is to be the germinal layer, a specialized band of nucleolated cells nearly encircling the egg and out of which the future caterpillar develops. The first step in this latter process is the division of the band by cross indentations into a number of segments, while at the same time the anterior portion increases in size; next, the rudiments of the various members, such as the mouth parts and legs, scarcely distinguishable in character one from another, bud out from the sides of the body. Thus the earliest form of the caterpillar may be called a segmented ribbon, with lateral buds where the movable organs are to be; and this ribbon is curled backward around the egg, head to tail. By degrees the ribbon broadens and fills out, or incloses the yolk-mass of the interior, the legs and other appendages grow, the mass of the body retreating at the same time to give them room, until, when the time of hatching approaches, the caterpillar has recovered its position in the egg, but with its back and not its belly next the wall of its prison. Finally, the circumference of the egg becomes too contracted for the rapid growth of the body, and the head and following segments of the creature are extended upward toward the summit of the egg, the hinder end overlapping the segments which fall in its way.

All these changes may transpire within four or five days, although they ordinarily take a fortnight, occasionally a month; and there are species of butterflies which pass the winter in the egg state.

CHAPTER II.

THE CATERPILLAR.

THE caterpillar is a worm-like animal, plainly separated into two principal parts, a head and body; and the latter into a number of rings, which may be clustered by certain features into two tracts, a thoracic and an abdominal. The head itself is in reality made up of a number of rings, consolidated in such a way as to render their separate determination one of the most difficult tasks of the morphologist, just as our own head is composed of a number of primal vertebrae. The hard parts of an insect are upon the outside, while ours are within; and just as our backbone is made up of a series of vertebrae ranged in a row, a single vertebra being, as it were, the unit of structure, so the outer coating of an insect is broken up into a series of rings, laid end to end, each the unit of its structure. The number of elemental rings forming the head of a caterpillar is still a matter of dispute, and would be a subject perhaps too abstruse in the present state of science to discuss here. It may only be said that no one ring will be found to bear on its under surface more than a single set of jointed appendages, and that the latest researches of Kowalevsky seem to point very directly to the conclusion that the head is composed of five primordial segments.

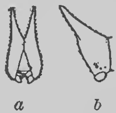


FIG. 19.—Head of caterpillar of Satyrodes Eurydice, × 2; *a*, front view; *b*, side view.

But the head, as it appears when the caterpillar fairly makes its entrance into the world, is a little globular case,* bearing beneath an astonishing number of movable organs, and having the upper part divided down the middle by a suture, which forks in passing down the face, leaving a triangular piece at the very front [Fig. 21]; this triangular piece bears the upper lip, a little flap of membrane with a swing forward and backward by means of the hinge which unites it to the triangle. Directly behind this come a pair of stout biting jaws or

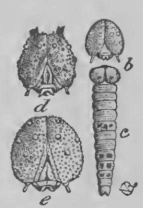


FIG. 20.—Anaea Andria; *b*, head of caterpillar, first stage, magn.; *c*, caterpillar in third stage, nat. size: *d*, head of same, second stage, magn.; *e*, head, fourth stage, magn. (Riley).

* The head of the newly-born caterpillar always lacks those prominences which frequently adorn the crown of the same creatures at later stages [Figs. 19, 20]. In the goat-weed butterfly (Anaea Andria) these attain their greatest size in the second stage, and afterward gradually disappear, so that the head of the full-grown caterpillar is as unbroken as when newly hatched (compare Fig. 20, *b*, *d*, *e*), while ordinarily these prominences increase in size with every moult, and may attain extraordinary dimensions (See Fig. 19 and Figs. 183 and 185, *i*, *j*, *k*, *l*, *m*).

mandibles, pyramidal, horny pieces, the chiselled or serrated edge of the one playing against that of the other as they work laterally. The mouth lies between them, and they are followed by more complicated parts, the secondary jaws, or so-called maxillae, which in many insects have a similar movement, and play no doubt a considerable part in the preparation of the food; but here they

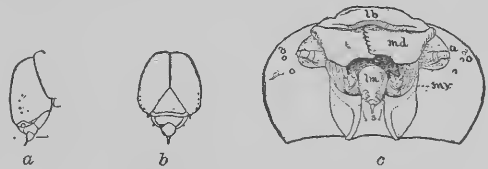


FIG. 21.—Head of caterpillar of Danais Plexippus; *a*, front view; *b*, side view, both × 3; *c*, view from beneath, × 10; *lb*, labrum; *md*, mandible; *mx*, maxilla, with two palpi; *lm*, labium, with one pair of palpi; *s*, spinneret; *a*, antenna (the bristle is not shown); *o*, ocelli (Burgess).

have only a certain telescopic motion of withdrawal and protrusion; they consist of a pair of rounded, fleshy, semi-globular prominences, and each of these has two appendages or feelers called palpi, the outer and larger composed of several joints, the inner of only one. The rest of the under and hinder part of the head is taken up with the labium or under lip and its appendages; though called in common language the under lip, it should not be compared or contrasted with the upper lip, but with the maxillae or secondary jaws, being in all insects of a similar composition, so as rather to merit the name of tertiary jaws. The opposing parts, however, never have any movement toward each other, but all are consolidated into a single piece. In caterpillars, the basal portion resembles that of one of the maxillae, and bears on either side at the tip a very minute jointed appendage similar in structure to the maxillary palpi, and to be compared with the outer of the two appendages of the maxillae ; they are termed the labial palpi ; between them it bears another appendage, the equivalent of united inner labial palpi, but having a special structure ; it is a conical slender horny tube, serving the purpose of the spinneret of the spider ; for, wherever the caterpillar walks, at least during its early stages, it sways its head constantly from side to side in a manner almost painful to behold, spinning a zigzag ladder of silk upon the surface on which it treads, by means of which its hold of the swinging leaf or twig is made more secure.

I am thus particular in describing the parts of the head in order to show how vast is the change they undergo in the growth of the insect. The pieces I have described are called in general the mouth-parts, and it is interesting to see with what astonishing compactness they are all massed together in one little spot. In the largest of our butterfly caterpillars, they would not together be larger than a pin's head. The only other movable appendages are the antennae, and these again are very similar to the maxillae. They are situated just at the base of the mandibles and consist of four joints, of which the first is only a fleshy lump, and the others very small cylindrical joints, each smaller than the previons, like the joints of a telescope, the last extremely minnte, and the last but one furnished with a long bristle. The eyes lie behind and above the antennae, and consist of six little hemispherical warts, five of them arranged in a curve opening backward, and the sixth at some distance behind.

The body, or the portion of the caterpillar lying back of the head, is composed of thirteen segments ; so far as external form, shape, and size are concerned, these segments do not often differ greatly from each other ; they are generally cylindrical rings a little shorter than broad ; but in the appendages they bear are found differences of great importance. Only the three segments immediately following the head bear horny and distinctly jointed legs ; bnt since the caterpillar would find it difficult to move freely in situations where it must seek its food without some prop to the hinder part of its body, it possesses besides five pairs of false legs, or prolegs as they are called, which for its purposes are even an improvement upon the genuine article [Fig. 22]. The true legs terminate in a horny claw and are encased in an armor-like shell which hardly allows anything more than a lateral motion [Fig. 23]; while

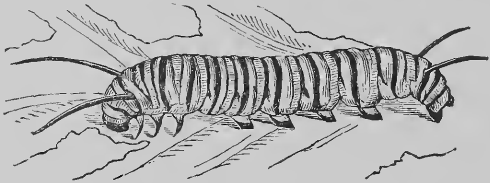


FIG. 22.—Caterpillar of Danais Plexippus, nat. size (Riley).

the proleg is a fleshy stub which may be withdrawn or extended at pleasure, and is armed at tip with several curving series of delicate hooks [Fig. 24]; these also are extensile and will grasp a single thread, or plunge themselves so firmly into a silken carpet that it would require considerable force on our part to extricate them; while a simple muscular movement of the caterpillar serves to withdraw them from the web, leaving not a thread misplaced. The presence or absence of the horny jointed legs separates the segments of which the body is composed into two tracts, the thoracic and abdominal; this separation, however, would not apparently have much weight were it not for the future development

FIG. 23.—Metathoracic leg of caterpillar of Papilio Antiopa, × $3\frac{1}{2}$.

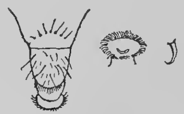


FIG. 24.—Caterpillar of Papilio Antiopa; *a*, proleg, × $4\frac{1}{2}$; *b*, circlet of hooks at end of proleg, × 5; *c*, one of the hooks, × 12.

of the creature, when the thoracic segments become the thorax and the abdominal segments the abdomen—a distinction which is merely foreshadowed now in the difference between the anterior and posterior feet. We have, therefore, chosen not to treat of these two tracts separately, but to discuss the different characteristics of the body as a whole, pointing out, however, some further distinctions between those which occur in the thoracic and those in the abdominal tracts. To return to the consideration of the legs, it should be noticed that while every one of the thoracic segments bears a true leg, it is not every one of the abdominal segments which bears a proleg. Indeed in the Lepidoptera generally there is considerable variation in this respect, but among the butterflies these appendages are always borne by the third to the sixth abdominal segments, and by the last segment, leaving thus a similar space without support between the true and false legs, and between the terminal and preceding false legs. In a single group of butterflies (Plebeii), that to which our tiny blues (Adolescentes) belong, the prolegs are excessively small, and can indeed only be readily detected when the skin of the caterpillar is prepared by inflation. These caterpillars seem to glide rather than to creep [Fig. 25]; and indeed their movements are undoubtedly aided by muscular contractions and expansions of the entire body, which fairly rests upon the surface of motion.

Another peculiarity of the body is a series of breathing-pores upon the sides, through which the air enters certain tubes ramifying within for the aëration of the blood; there is but one of these spiracles or stigmata upon either side of any segment, and they are absent from the second and third thoracic and from the last two abdominal segments; it would appear therefore that the narrowing hinder portion of the body can be supplied with air from the segments in advance; but the absence of spiracles from what is ordinarily the stoutest part of the body, the centre, too, of the greatest variety and largest development of internal organs, requires another explanation; and it is to be found only in the fact that the spiracles are absent from these same segments in the perfect insect, where they would interfere with the special purpose of this part of the body, viz., the support of the wings and of the apparatus for their vigorous movement. *Here we have a*

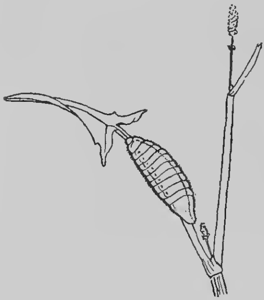


FIG. 25.—Caterpillar of Heodes Hypophlaeas, nat. size.

significant foreshadowing of the approaching winged state of the insect.

One more feature common to several segments of

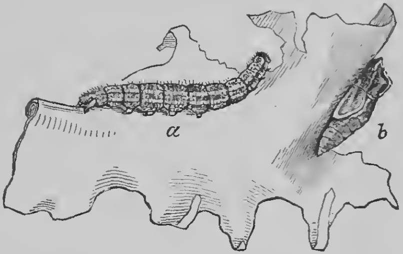


Fig. 26.—Pontia Protodice; *a*, caterpillar; *b*, chrysalis; nat. size (Riley).

the body of a caterpillar is its abundant armature. No caterpillars of butterflies are absolutely naked; those which appear so are still clothed with delicate pile [Fig. 26], or short distant bristles, which are more or less regularly disposed; others are covered with simple or compound spines [Fig. 27], or with microscopically barbed hairs of great length, or with fleshy filaments [Fig. 28; see also Fig. 22], or clubbed or knobby tubercles [Fig. 29; see also Figs. 40, *a*, *b*, *c*], whose definite arrangement is still more apparent; ordinarily they are disposed in longitudinal rows, with one or more spines on

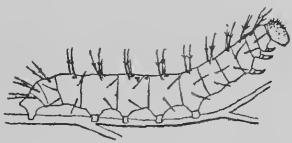


Fig. 27.—Caterpillar of Papilio Antiopa, nat. size.

each segment, and all the spines of one row will be found on corresponding points of the different segments, either at the front, or back, or centre, as the case may be. The first thoracic segment, however, takes little part in these regular series; its appendages are usually reduced to a transverse series next the front edge, often forming a sort of crown to the head; still they may severally be proved to form part of the longitudinal series of the rest of the body, or rather of the thoracic segments; for with scarcely an exception among the caterpillars of butterflies, those series which extend along the abdominal segments either stop altogether at the thoracic segments, or slightly change their direction at this point; so

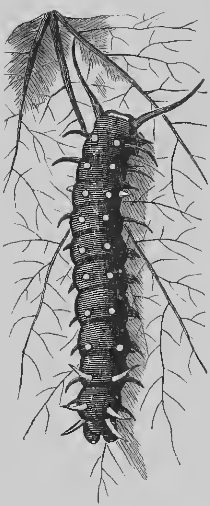


FIG. 28.—Caterpillar of Laertias Philenor, nat. size (Riley).

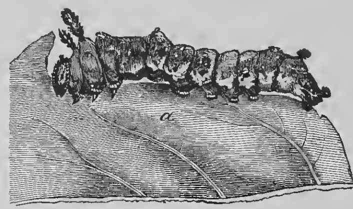


FIG. 29.—Caterpillar of Basilarchia Archippus, nat. size (Riley).

that often we may readily distinguish the thoracic from the abdominal segments without seeing the legs. *Thus even in the mere disposition of the spines on a caterpillar's back, the future separation of thorax and abdomen is foreshadowed.*

It might be supposed that the slightly altered arrangement of the spines in passing from the abdominal to the thoracic tract was due to the larger amount of space on the latter owing to the absence of breathing pores ; but it is wholly independent of this, for when the spines are well developed on the first thoracic segment, which bears an unusually large spiracle, they align with those of the other thoracic segments and not with those of the abdomen.

In many caterpillars there is some difference in the relative size of the various segments ; generally speaking, the segment behind the head is rather smaller than the others ; and in one group, the skippers (Urbicolae) [Fig. 30], as also in the goat-weed butterfly [see Fig. 97], it is reduced to such a narrow neck as to give the creature a strangled appearance. In another group, on the contrary —that to which some of our smallest butterflies belong, the coppers (Villicantes), blues, and hairstreaks (Ephori)—this segment is largely developed, while at the same time the head is smaller

FIG. 30.—Caterpillar of Atrytone Zabulon, nat. size.

in proportion and absolutely retractile within this segment, so that when the creature is not feeding its head is invisible [see Fig. 25]. In another group, the swallow-tails, an approach to this state is seen in the concealment of the hinder half of the head by a fold in the cuticle of the segment behind [Fig. 31]. Any striking differences of size seen in the middle segments of the body are generally due not so much to the enlargement or contraction of single segments as to the presence, at such points, of fleshy tubercles [see Fig. 29]; but the body always tapers somewhat posteriorly, and the last two segments (especially in the blues and their allies) are generally so closely coalesced as readily to be mistaken for a single one.

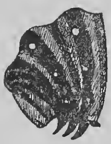


Fig. 31. — Front portion of caterpillar of Princeps Polyxenes, to show the partial covering of the head by the first thoracic segment, × 1⅓.

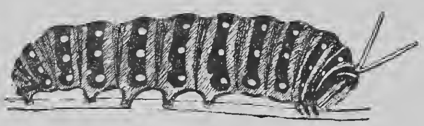


Fig. 32.—Caterpillar of Princeps Polyxenes with extended osmateria, nat. size (the head is drawn too large).

It only remains to speak of a certain isolated extensile organ borne by the first segment behind the head. I refer to the prong, termed, in the swallow-tails (Equites), the osmateria or scent-organ [Fig. 32]; it is here developed to an extraordinary degree, having, when extended, a Y-shaped form, but when not required for defence entirely retracted within the body, leaving only a transverse slit to indicate its point of emission [see Fig. 28]. In all other butterflies the organ is found upon the under surface of the body between the lower lip and the front legs, and its identity with the osmateria has therefore escaped attention. In this place it is never developed as a Y-shaped organ, but is protruded as a conical or hemispherical bladder of greater or less size [Fig. 33], or, in the blues and their allies, as a lenticular disk. It is found also in many other Lepidoptera; whether developing externally upon the upper or under surface of the body, it is always, excepting in the anomalous group to which the blues and similar butterflies belong, emitted from a transverse slit across the segment. Its use, when developed on the upper surface, is unquestionably as a scent-organ, a weapon of defence against its foes, for the stench it emits in some species is simply insufferable; when developed beneath, the purpose of this organ is problematical; some have supposed that it secreted a fluid for the lubrication of food just before eating, but this seems exceedingly doubtful.

FIG. 33.—*a*, front portion of the caterpillar of Danais Plexippus, to show the bladder on the under surface of the first thoracic segment, × 2; *b*, the bladder seen from beneath and behind, to show the transverse slit at tip, × 2.

Other similar extensile organs are occasionally found in different parts of the body in Lepidoptera; but among butterflies they have been noticed only in some of the caterpillars of the blues, which, when disturbed, extrude a very minute vesicle from a transverse slit on the top of the seventh abdominal segment. This was first noticed by Guenée* nearly fifteen years ago, but his observations attracted little attention until the fact was rediscovered in this country by Mr. Edwards,† who also noticed and explained the use of still other extensile organs on the next segment of the body in the same caterpillars [Figs. 34, 35], mentioned by Guenée, and now known to occur in many blues. The central vesi-

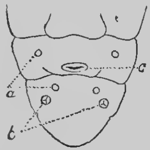


FIG. 34.—Top view of terminal segments of the caterpillar of Cyaniris pseudargiolus; *a*, spiracles; *b*, position of extensile organs shown in Fig. 35; *c*, opening of vesicle, which is capable of emitting a fluid; × about 6 (Edwards).

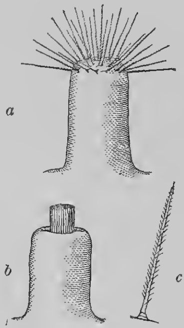


FIG. 35.—Extensile organs on the caterpillar of Cyaniris pseudargiolus; *a*, with the spines expanded; *b*, with the spines half withdrawn; both × about 30; *c*, one of the spines still further enlarged (Edwards).

* Ann. Soc. Entom., France, (4), vii., 665–68 (1867).

† Can. Entom., x., pp. 6,136 (1878). See also Mr. McCook's observations, made independently the same year, in the Trans. Amer. Ent. Soc., vi., pp. 289–91.

cle of the seventh segment exudes a sweetened fluid, very grateful to ants, and the spiny-crowned tentacles on the next segment serve, when erected, as indications to the ants that the feast is ready. The ants in their turn act as guards to keep off the attack of Ichneumon enemies from their willing hosts, and thus each serves the other a good turn.

These are all the external parts of a caterpillar which it is now necessary to consider. But there is one peculiarity of its growth, which, though very curious, has been but little noticed, and only recently has been shown to be of probably universal application. When any one characteristic is found throughout an entire group we naturally inquire what its meaning may be; especially in these days when evolution is required to explain everything or nothing. In this place, I shall only present the facts, and leave a possible explanation for a later chapter.

Every caterpillar in its growth from the egg to maturity changes the character of its coating. I do not refer to that periodic sloughing of the integument common to the early stages of all insects, the reason for which is quite apparent, since otherwise their inelastic coats would be too strait for their rapidly growing bodies. But I call attention rather to the fact that with the first sloughing of the integument an entirely different set of appendages is assumed. The fresh integument of subsequent moultings may be likened to a new spring suit, very like the old one, but bright and clean; while the difference of armature accompanying the first moult is more like the difference between the dress of a child and a man. The dress of our manhood differs as much from that of our infancy as it does from the dress of a savage; in like manner the outfit of a full-grown caterpillar differs as much from its outfit at birth as it does from that of a caterpillar belonging to a different tribe.

To present a few examples: The mature caterpillars of our brown meadow butterflies or satyrs (Oreades) have a rough skin, the result of a multitude of minute tubercles; each of these tubercles bears a simple hair, scarcely visible to the naked eye. In the young caterpillar of four different genera of these butterflies which I have studied, the skin is smooth, and instead of being supplied with an almost innumerable number of microscopic hairs, is furnished, in some instances, with an exceedingly scanty number of little club-shaped bristles, proportionally many times longer than the hairs of the adult, and arranged in definite longitudinal series [Fig. 36]; in others it is furnished with flattened ribbon-like hairs, as long as the body, serrated on one edge and bent in the middle

FIG. 36.—Bristle of young caterpillar of Satyrodes Eurydice, × 125.

[Fig. 37]; on the abdominal segments these hairs point backward, and on the thoracic forward; that is, the caterpillar parts its hair in the middle [Fig. 38]. In the Monarch or Milk-weed butterfly (Danais Plexippus) the full-grown caterpillar (see Fig. 22) is naked, but adorned with a pair of long, thread-like, fleshy, flexible tentacles at either extremity of the body; in the young caterpillar these tentacles or filaments are absent, but their future position is marked by little, conical, black points, while the body is covered with minute black bristles, arising from still more minute warts, and arranged six on the back of each segment, placed four in a row in front and one on each side behind, and three on either side of the body, one in the middle of the segment and two below [Fig. 39]. In our purples the segments of the young caterpillar are equal in size and have regular series of stellate warts; in the mature caterpillar the body is grotesquely hunched, while

Fig. 37.—Ribbon-like bristle of young caterpillar of Cercyonis Alope, × 125.

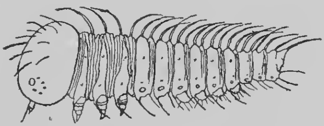


Fig. 38.—Young caterpillar of Cercyonis Alope, × 20.

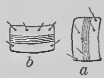


Fig. 39. — Side view (a) and top view (b) of young larva of Danais Plexippus to show the arrangement of the hairs, × 20 (Riley).

the warts have changed to very variable tubercles, one set, mounted on the highest hunch, presenting a formidable appearance as a pair of knotted clubs as long as the breadth of the body [Fig. 40]. In the angle-wings (Praefecti), which furnish the ordinary spiny caterpillars, these spines are compound in the adult (that is, they bear subsidiary spinules), and are arranged in certain definite rows. In their earliest life, these caterpillars are furnished with long tapering hairs [Fig. 41] also arranged in definite series, but not occupying the same position as the spines of the mature caterpillar. Now in each genus of spiny caterpillars the spines occupy a certain fixed place, and by means of this feature, among others, we define the genus. Here then the young and old caterpillars plainly differ from each other in generic features. To a casual view the caterpillars of our blue butterflies, our coppers and hair-streaks, appear quite naked; they are, however,

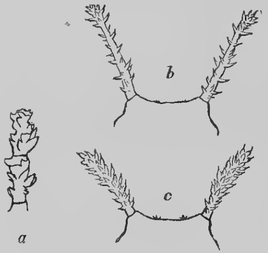


FIG. 40.—Clubbed spine of caterpillar of Basilarchia Astyanax (*a*), × 3, and of B. Archippus (*b*, *c*), × about 3.

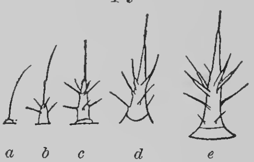


FIG. 41.—Spines of caterpillar of Vanessa cardui at different periods—*a*–*e*, first to fifth stages; differently magnified.

profusely covered with microscopic hairs; but the newly hatched caterpillars are provided with long hairs sweeping backward behind their bodies, most of them arranged in longitudinal series [Fig. 42]; the hairs themselves, too,

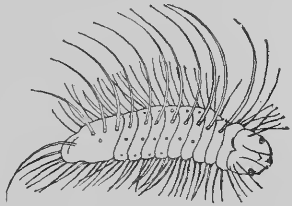


Fig. 42.—Young caterpillar of Heodes Hypophlaeas, × 28.

instead of being simple, as in the adult, are covered with microscopic spicules. In our white and yellow butterflies (Fugacia and Voracia), the pests of the garden and the glory of the fields, the differences between

Fig. 43.—Spine of young caterpillar of Eurymus Philodice, × 300.

youth and old age are much the same as in the meadow butterflies first mentioned [Figs. 43, 44]. In a general way, the same may be said of the skippers, but the appendages of the new-born caterpillar are always shaped like little clubbed mush-

Fig. 44. — Spine of young caterpillar of Pieris oleracea, × 80.

rooms [Fig. 45], and under the microscope bear an odd resemblance to a row of cabbages in a vegetable garden. The caterpillars of our swallow-tails, at least of those common in New England, are always nearly naked

Fig. 45.—Heavily clubbed or trumpet-shaped spine of young caterpillar of Ocytes Metea, × 150.

when full grown; we may find a few scattered hairs by searching with a lens, and here and there a minute tubercle, or a smooth and shining wart; in some species the front part of the body is swollen and furnished with striking eye-spots; at birth, however, the body is always perfectly cylindrical and supplied with several prominent series of bristle-bearing tubercles, one tubercle to a segment in each row, and one row in the middle of the sides more conspicuous than the others.

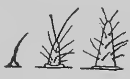


FIG. 46.—Spines of caterpillar of Cinclidia Harrisii at different periods—*a*, first stage; *b*, third stage; *c*, fourth stage, differently magnified.

Instances have been given in every one of the larger groups of butterflies to show the universality of this feature in the development of the caterpillar; many of the changes are gradual in their appearance, as shown by the accompanying figures [Fig. 46] of the spines of the caterpillar of Harris's butterfly (Cinclidia Harrisii) [Fig. 47] at different stages, where, it will be seen, they grow more complicated with advancing life; or they may be seen better still in those of the caterpillar of the Painted Lady (Vanessa cardui), as shown in Fig. 41, where the spines of each stage are shown; but the more important changes between the different stages of a caterpillar's life occur at the first moulting; that is, those features of the young

FIG. 47.—Chrysalis of Cinclidia Harrisii, nat. size.

caterpillar not possessed by the adult are those which it has brought with it from the egg, and which are lost when its skin is first cast. We should, therefore, naturally suppose these peculiarities to have some reference to its condition in the egg ; but this view cannot be maintained for a moment, for certainly the most appropriate condition for a caterpillar in the egg would be entire absence of clothing or a uniform covering of silky hairs, conditions which are exactly the ones which do not occur. On the contrary, in every instance we can find, caterpillars which at maturity are naked or nearly so, or clothed uniformly with hair, when newly hatched bristle with tubercles or are supplied with cumbrous serrated or spiculiferous hairs. Some other explanation must therefore be sought, but we are not yet prepared to discuss it.

A caterpillar, then, is a cylindrical jointed creature, having several of the front segments consolidated to form a horny head, with numerous mouth-parts, eyes, and antennae all crowded together at the bottom ; three other segments succeeding it bearing horny legs ; and most of the remainder supported by fleshy legs furnished with microscopic hooks ; all the body segments are furnished with special appendages, which, during some stage of its development, are arranged in definite series.

CHAPTER III.

THE CHRYSALIS.

The change undergone by a butterfly in passing from the caterpillar to the chrysalis state has always excited great interest ; yet, notwithstanding all that has been written on the subject, mostly modelled upon the detailed but not wholly accurate account given more than a century ago by Reaumur, the method by which the chrysalis inclosed within the larval skin becomes attached to the silken button into which the hindmost feet of the caterpillar had previously been plunged, has never been rightly explained until within a very few years, when the observations of Osborne in England, and of Edwards, and especially of Riley, in our own country, have solved the problem. The process is the most extraordinary in the higher butterflies, which suspend themselves in pupation by the hinder end only, without first spinning a loop, like other butterfly larvae, for the support of the anterior, heavier part of the body. A caterpillar of this kind preparing for pupation spins a loose mass of silk in some suitable place, and, firmly attaching itself to it by the hooks of the anal prolegs, casts itself loose from all other support, and hangs by the tail [Fig. 48]. It next curves the front part of its body upward on the ventral side, and after a time, when the front part of the body has become greatly swollen by the descent of the body fluids, a rent is produced

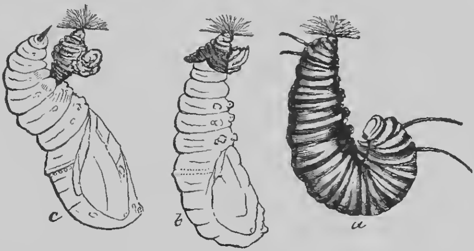


FIG. 48.—Danais Plexippus, changing from caterpillar to chrysalis ; *a*, caterpillar just before the rending of the skin ; *b*, chrysalis just before the cremaster is withdrawn ; *c*, chrysalis just after withdrawal of the cremaster (the last is a little inaccurate)—compare the form of the chrysalis with that it finally assumes, Fig. 61 (Riley).

in the back of the caterpillar, and the chrysalis gradually protrudes ; not as it will afterward appear, but a limp, soft, and rather shapeless mass. It now hangs at full length, and the thin integument of the caterpillar, by the mere shrinkage which necessarily follows its drying, creeps back toward the button of silk to which it is attached ; ligamentary elastic membranes, which protrude from the anal and tracheal openings at the extremity of the body, keep the chrysalis from falling out of the nearly emptied larval skin ; but it is not destined to remain hanging by these uncertain and delicate supports ; when all is ready, the very extremity of the chrysalis, a long and horny piece, armed at tip by a multitude of recurved spines, is carefully withdrawn, and the now partially hardened chrysalis, supported by these ligaments, and in part, probably, by the larval skin itself, gripped between the edges of some of the hinder segments of the body, hangs entirely without the larval skin which formerly inclosed it ; by slight twisting of the body, aided by the elastic nature of the ligaments, the cremaster, or terminal piece of the chrysalis, finds its way to the button of silk, into which the hooks at its tip are soon entangled ; by writhings and whirlings of the body, a greater and greater number become more and more deeply embedded, while at the same time the rapid drying of the now useless ligaments causes their rupture from the larval skin, which, shrivelled and loosened, drops to the ground, leaving the chrysalis in firm possession of the button of silk.

What a different object now greets our eyes ! Instead of the worm with soft and fleshy body, greedy of food, moving where it will, we find a toughened mummy, incapable of more motion than a feeble wriggle, and otherwise apparently lifeless ; what few prominences it can boast are seldom greatly elevated above the surface, and in none of our native species ever assume the form of spines, so common in the caterpillars, or of hairs, excepting such as are microscopic ; there are no movable appendages whatever.

We mentioned certain features in the body of caterpillars as dividing that portion into two tracts, foreshadowing the separation of thorax and abdomen in the perfect insect ; but here, in the intermediate stage, even the wide distinction between head and body is lost, and the whole creature appears in one compacted form, the impressed lines marking the boundary between head and thorax or thorax and abdomen being no more distinct than those separating any other two segments. In the general contour of the surface, however, the thorax is distinctly separated from the abdomen ; while the head is seldom separated in a similar way from the thorax [Fig. 49] ; thus our new acquaintance is represented by two oval masses placed end to end and blended, the front portion representing the head-trunk or cephalothorax and the hind portion the abdomen. The appendages of the chrysalis are all encased in separate sheaths, which, when it first emerges from the caterpillar skin, can readily be separated from one another, but afterward become consolidated with the rest of the integument, and are neatly folded over the

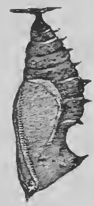


Fig. 49.—Chrysalis of Papilio Antiopa, nat. size (Harris).

front of the body [Fig. 50]. These appendages belong to the butterfly and differ widely from any feature in the caterpillar; the wings, therefore, naturally occupy the larger space, their tips meeting or nearly meeting in the middle line of the belly; next their upper edge lie the antennae, which are followed by some of the legs, while down the middle, between these, lie the two parts of the maxillae or tongue. As, however, there are not sheaths enough in sight to accommodate all the legs, it becomes a question of some interest to know where they all are, and which pairs are exposed. This is not easy to decide from an examination of the surface of the chrysalis alone, but if a forming chrysalis be examined while the organs are movable, or the creature be dissected, it is easy to see, first, that all the legs are bent at the femoro-tibial articulation, so that only the tibiae and tarsi of any of the legs are exposed; then that the hind tibiae and tarsi are concealed beneath the wings, just as they are in a large number of pupae of beetles or other insects, where they can easily be seen because they are not consolidated with the body; the parts, therefore,

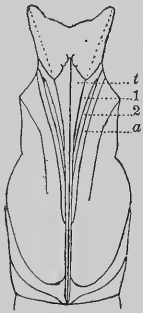


Fig. 50.—Ventral view of front portion of chrysalis of Euphoeades Troilus, to show the sheaths of the appendages of the head and thorax; × 2; *t*, tongue-sheath; 1, first pair of legs; 2, second pair of legs; *a*, antennal sheath.

exposed to view in the hardened chrysalis are the tibiae and tarsi of the front and middle legs. In front of and lying between the anterior legs is another pair of sheaths whose inner edges unite along the middle of the body and which at base are broader than the legs, but which taper to slender parallel threads; these generally extend to the wing-tips, pushing their way between legs and wings, which thus abut against them; these are plainly the sheaths in which lies the slender elongated tongue of the butterfly, but the extent of the basal portion is beyond all need, and some writers have asserted that they formed the covering for the front legs as well as the tongue, and that the sheaths which really encase the front and middle legs covered the middle and hind legs respectively. If the naturalists who first made this discovery had but used the scalpel for five minutes, their mistake would never have occurred [Fig. 51]. In reality this expanded base of the sheath covering the tongue affords protection also to the palpi which lie beneath and beside the tongue; yet even in those groups where the palpi are small and the front legs long,

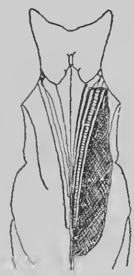


FIG. 51.—The same as Fig. 50, with the covering of the legs and part of the wing of one side removed, to show how the hind tibia and tarsus are concealed beneath the wings; × 2. The third pair of legs is seen below the antennae.

the proportionate extent of this part is still the same; showing that the sheath is expanded at this point simply to fill up the angular void left on obliquely uniting legs from opposite sides of the body, and that the surface we see is a common lid under which are thrust the tongue and the palpi. There is another curious thing about this part; very frequently the base of the tongue is not covered by this lid at all, but by a separate piece of its own [Fig. 52], which, unlike the lid beyond, is not divided down the middle to represent the two halves of the tongue. This appears to be a constant phenomenon in some butterflies; but in others (compare Figs. 50 and 51) it is sometimes present and at others absent; that the tongue itself is not exposed at this point is proved by its being formed of a single, not, as the tongue itself, of a double piece.

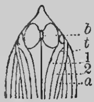


FIG. 52.—Ventral view of the front portion of the chrysalis of Eurymus Philodice, showing the separate piece covering base of tongue; × 2; *b*, basal tongue-piece; *t*, tongue sheath; 1, first pair of legs; 2, second pair of legs; *a*, antennal sheath.

Next the extreme base of the tongue, and abutting against it on either side, are the mandible-cases, small plates, not separated at their base from the integument of the head, and often reduced to mere tubercles; indeed their appearance is so slight that I do not know if their existence has ever been specially noticed.

On either side of the head, close to the base of the antennae and partially overlapped by them, is a smooth crescent-shaped belt, which corresponds closely in position with the curving row of simple ocelli in the head of the caterpillar, where it is generally marked by a distinct impression; it also lies across the middle of the convexity which marks the position of the compound eye of the inclosed butterfly; the convex case of the rest of the eye is rough and coarse like the chrysalis skin generally, but this curved ribbon is smooth and thin, and regularly embossed, each gentle elevation apparently corresponding to the centre of a facet of a compound eye [Fig. 53]. Now it has been suggested that this belt is a window through which the prisoner may look abroad; what end this would serve is not explained; nor have the structure, form, and position of the belt been taken into consideration, or, so far as I am aware, even stated. Two things, however, may be remarked: first, that no underlying structure has been found related to it alone; second, that as an external covering of an eye its structure is midway between that of the caterpillar and the perfect insect. May it not be a relic of the past, the external sign of what once was? And are we to look upon this as one hint that the archaic but-

FIG. 53.—Head of chrysalis of Euphoeades Troilus; side view to show the eye; × 2.

terfly in its transformations passed through an *active* pupal stage, like the lowest insects of to-

Fig. 54.—Chrysalis of Polygonia Faunus, nat. size.

day, when its limbs were unsheathed, its appetite unabated, and its daily necessities required the use of a compound eye, such as would result from the multiplication and conglomeration of simple eyes within the normal ocellar field of the larva? These, it is true, are merely speculations; but we must not rest satisfied with any explanation of the structure of this glassy band which does not account for its form and its relation to the larval row of tubercles.

Fig. 55.—Chrysalis of Lerema Accius, nat. size.

There is another peculiarity in the head of

Fig. 56.—Chrysalis of Eurymus Philodice, nat. size (Harris).

certain chrysalids which demands our attention and an explanation of its cause, since it is found in some groups and not in others. On either side of the head there is often a roughened angulate or conical projection, bearing no relation whatever to the parts beneath, but looking like a pair of clumsy horns or ears projecting forward [Fig. 54; see also Figs. 49 and 50]; other chrysalids have the front extremity prolonged in the middle [Figs. 55, 56; see also Fig. 52], while the sides of the head are quite smooth and regular; others again have the same smooth and bluntly rounded head [Fig. 57] which generally characterizes the pupa of moths. Since these projections are mere extensions of the pellicle and quite hollow, it might be presumed that they indicated some variation in the life of the chrysalis; and such indeed is the fact. Many chrysalids are protected by some sort of a cocoon; and these have perfectly smooth and rounded heads; so, too, have those which, though exposed, are girt immovably to the object they have chosen as their support [Fig. 58]. Other chrysalids are attached by the tail and

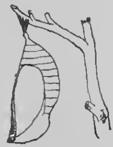


FIG. 57.—Chrysalis of Cercyonis Alope, nat. size.

FIG. 58. — Chrysalis of Heodes Hypophlaeas, nat. size.

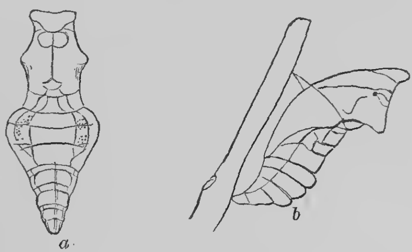


FIG. 59.—Chrysalis of Laertias Philenor, nat. size; *a*, dorsal view; *b*, side view. (After Harris.)

loosely bound about the middle by a girth which allows the body to sway from side to side [Figs. 59, 60]; while still others hang freely by their hinder

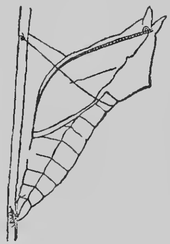


FIG. 60.—Chrysalis of Euphoeades Troilus, nat. size.

extremity. In these two latter cases the chrysalids may be blown hither and thither by every breeze and are liable to injury from neighboring objects; their point of greatest motion is of course the head, and this, therefore, is guarded by projecting roughnesses. In those which hang freely there are some exceptions to this rule, as in the case of our Milk-weed butterfly [Fig. 61], but even here little conical tubercles may be discovered; and, besides, the chrysalis stage of this species is passed in midsummer, and therefore is very brief. So far as I am aware, *every chrysalis which lives through the winter, and whose body hangs at the mercy of the wind, has its head protected* as I have described; those which hang freely have always the two frontal projections; those which are also loosely girt about the middle sometimes have the same; or they may have the single ex-

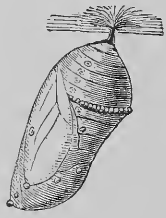


FIG. 61.—Chrysalis of Danais Plexippus, nat. size (Riley).

tension in front. It may also be noticed that chrysalids with extraordinary projections or ridges in other parts of the body all belong to the same free-moving groups [Fig. 62; see also Fig. 59]; the greater the danger to the chrysalis from surrounding objects, the greater its protection by horny tubercles and roughened callous ridges; the greater the protection possessed in other ways, as by firm swathing or a safe retreat, the smoother the surface of the body and the more regular and rounded its contours.

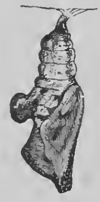


Fig. 62.—Chrysalis of Basilarchia Archippus, natural size (Riley).

During the caterpillar stage, the three joints corresponding to the thorax of the future butterfly are of nearly equal size, each having one pair of legs; in the butterfly, however, the second and third joints also bear the wings, which become the principal, we might almost say exclusive, organs of motion; these joints therefore are developed at the expense of the first; and as the front wings are always larger than the hinder pair, and by their position require more muscular force, the joint of the thorax which supports them is always proportionally larger. The preparation for this necessity is seen in the chrysalis, where the wings are already developed; to a great extent this is true even in the blues and their allies, in which the prothorax of the larva is immensely enlarged, permitting, as we have seen, the entire withdrawal of the head.

There is only one other point in connection with the thorax which need detain us. In the caterpillar we found a spiracle in the middle of the side of the first ring. In the chrysalis, however, we have shown that the middle joint of the thorax is developed at the expense of the front joint, and the latter is further curtailed by the sheaths covering the extended mouth-parts to such a degree that it is reduced externally to a slender dorsal plate ; the spiracle is therefore transferred to the suture between the outer portion of this dorsal plate and the middle joint ; indeed it seems rather to belong to the latter, for it is often protected at this point by a thickening of the middle joint, occasionally developing to a tubercle [Fig. 63] ; this spiracle and those upon the sides of the abdominal joints are the only openings into the interior of the body ; the digestive tube is closed at both ends ; no glands find an external outlet, and so little aëration is required for the fluids of the body during its strange dormancy, that in the higher groups this thoracic spiracle is lost and the larger part of the body receives its air through the openings at the op-

Fig. 63.— Front portion of chrysalis of Epargyreus Tityrus, showing thoracic spiracle at * ; × 2.

posite end and the secondary channels which course along the body.

The abdomen is always of a subconical shape, tapering toward the hinder extremity, and more or less constricted where it joins the thorax. The spiracles remain in the same position as in the caterpillar, excepting on the first segment, which is so far covered by the folded wings that the spiracle is lost, and the segment reduced to a small dorsal plate ; at the extremity of the body, however, an apparently new structure is developed, the cremaster, or anal button, a slender tubercular prolongation at the extremity of the body. Riley, however, has shown* that it is not a new structure, but that it corresponds to the anal plate (or hindmost segment) of the caterpillar. Künckel indeed contends† that it represents the soldered anal prolegs of the caterpillar ; but Riley clearly proves that these are represented in the chrysalis by what he calls the sustentors, ridges on the ventral surface which terminate anteriorly in little knobs or hooks, and play an important part in pupation. The form of the cremaster varies considerably in different groups, but always bears on its tip, or under surface, or on both, a crowd of microscopic recurved hooks [Fig. 64], which, in chrysalidisation, are

* Amer. Entom., iii., 162–167, July, 1880.

† Comptes Rendus, xci., 395–397, August, 1880.

plunged into the silk the caterpillar has spun for the purpose, and, becoming entangled in it, keep the chrysalis in place. In the family of blues and hair-streaks, where the chrysalis is bound closely to the surface of rest, and the last joint of the abdomen is curved under the body, these hooks are seated upon the segment itself, but in all the others there is invariably some prolongation of the tip, which bristles with hooks.

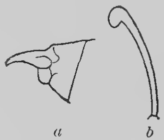


FIG. 64.—*a*, Last segment of the body of the chrysalis of Epargyreus Tityrus, showing the cremaster, × 2½; *b*, one of the hooks of the cremaster, × 43.

By this review, we see how admirably the form and projections, the position and inactivity of the chrysalis are adapted to its purpose. Great changes are to transpire in the hidden recesses of the body; the outer integument becomes a compact, hardened case, protected at every needed point by roughened projections or callous shoulders; all the appendages are securely ensheathed and so cemented to the outer integument as to form part and parcel of it, without disturbing its contours; all unnecessary openings are firmly closed, and those that remain are carefully guarded by dense callous spots; and in addition hooked claws, attached to the thickened tail, fasten the swinging mummy securely in its place. From this inert mass shall suddenly spring, like wellclad Minerva from the head of Jove, a creature of no apparent kinship either with the case that enwrapped it or the lowly worm that preceded the chrysalis ; a creature with soft, elastic body, buoyant as the air in which it floats, with spreading feelers and broad-spanned wings, clothed with jewelled dust and silken hair, which reflect the colors of the rainbow, and in their delicate combinations defy the painter's palette. But how did such a creature, whose plumage is ruffled by a breath of wind, escape from its iron prison, hardened by months of exposure to wintry cold and sleet and sun in rapid succession? There is a weak point in every structure, and in the chrysalis it lies next the point of greatest strength in the captive butterfly. The butterfly never emerges in winter, but when the more genial showers of spring or the damp air of a summer's night have softened the texture of its prison-walls, they are further weakened by the moisture now exuded by the twice-bound prisoner feeling the hour of final release draw near. A suture along the crest of the thorax gives way, often with a perceptible click, to the force of the great muscular mass within ; the rest is easy ; the rent is continued on both sides down other sutures, until a door is open, whose smooth inner walls suffer no harm to the delicate creature struggling to escape. Slowly the limbs are withdrawn from their encasements, cautiously the butterfly climbs the friendly twig that has been its support, and sitting in the sunshine dries its moist quivering wings, gently fanning them up and down, until, full of new life and courage, it ventures forth—a thing of beauty and a joy forever.

CHAPTER IV.

THE BUTTERFLY.

More than fifty years ago, that prince of dreamers, Oken, wrote as follows :* "The insect passes through three stages prior to its attaining the adult or perfect condition. It is at first Worm, next Crab, then a perfect volant animal with limbs, a Fly."

How sagacious this observation was appears from what we have already seen. In external form the caterpillar so closely resembles a worm that in common language it is often so called ; it drags its whole length upon the ground ; its body consists of a series of rings placed end to end ; its head, it is true, is more or less separated from the rest of the body, but yet agrees so well in general size and form with the segments behind that the distinction only appears upon examination ; while the difference between the joints forming the future thorax and those of the abdomen can only be traced by careful study. In the pupal stage, although the line of separation between thorax and abdomen is well marked, and the latter is

* Elements of Physiophilosophy, Engl. ed., p. 542.

composed of many joints movable one upon another, all special distinction between the head and thorax is lost, and their segments are immovably soldered into one common tract. This is an exact temporary repetition of the more important distinctive features of the crab and lobster, where the head and thorax are united by a common shield into a cephalothorax, while the joints of the abdomen are freely movable. This, then, is what Oken meant when he pointedly calls the pupa, Crab.

When we reach the final stage of the butterfly's life, which we shall now consider, we find its prime distinction to be the clustering of the joints of its body into three perfectly separate regions—head, thorax, and abdomen, each with its peculiar and differently developed appendages.

Now, since the worm-like or larval stage of insects is the most immature, and the crustacean or pupal stage lies intermediate between it and the perfect form, Agassiz urges, in his remarkable "Essay on the classification of insects,"* that worms, crustacea, and insects are three classes of one type of the animal kingdom, of which worms must be considered the lowest and insects the highest. On the same ground he divides the insects themselves into three groups, and places

* Smithsonian Contribution to Knowledge, vol. ii.

lowest among them the myriapods, as caterpillar or worm-like insects; in the middle place the spiders, as pupal or crustacean insects; and highest of all the true or hexapod insects with their triregional body.

How far-reaching, then, is the relation between the earlier and the perfected form of insects, and of how much importance it is to study the successive stages of development of animal life. Do we not here see, too, what indissoluble bonds unite the general features of structure among allied creatures and the historical development of each? How complicated, comprehensive, divine a plan runs through the organization and relationship of animal life! Unless we can in some measure comprehend and regard that plan, we lose sight of at least one chief end of the prodigality of nature—the harmony of divine and human thought.

Let us pass now to the consideration of the changes which the different parts and organs of the insects we are discussing have undergone. We shall compare these directly with the corresponding parts of the caterpillar, because, in treating of the structure of the chrysalis, at least so far as the appendages are concerned, we have really described the appearance, not of the appendages themselves, but of the sheaths in which they were inclosed. In reality the difference between the chrysalis and the imago is far less than that between the caterpillar and the chrysalis, the wrinkled sheaths of the chrysalis confining parts which differ in little more than size from the perfected organs of the imago. It is into the period of quiescence at the close of the caterpillar state, a period of only twenty-four to forty-eight hours, that are crowded nearly all the really wonderful alterations of structure in these insects, alterations which affect not only the form and relationship of the external parts, but also those of all the internal organs.

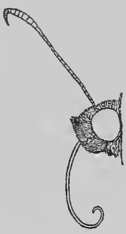


Fig. 65.—Side view of head of Epargyreus Tityrus, nat. size.

The head of the butterfly [Fig. 65] differs somewhat in general form from that of the caterpillar, the sides being greatly enlarged and occupied by a pair of compound eyes of enormous extent, supplanting the minute area occupied by the simple ocelli of the larva, or the more extended and highly organized ocellar riband of the pupa; these eyes are convex hemispheres, whose face is divided into innumerable hexagonal facets scarcely more than one-hundredth of a millimetre in diameter, arranged with great regularity, each with its underlying structure of rod and nerve, representing a single eye.

The immense development of the eyes has quite altered the relation of the different parts of the head ; in the caterpillar the antennae lay directly beneath the crescent of ocelli ; in the butterfly, on the contrary, they are situated directly above the eyes ; the expansion of the ocellar field has been at the expense of the parts above it, and in this contraction the antennae have passed upward in front of the growing ocellar field until they are found quite above it. In the perfect stage of many of the lower lepidopterous insects, and in a single one of our butterflies, a pair of ocelli are found directly behind the antennae, and are, apparently, the hindmost of the larval ocelli, which, it will be recollected, form no part of the little crescent in which the others fall, and do not modify the form of the pupal ocellar riband ; these ocelli have passed around the growing ocellar field on the opposite side, to find themselves at last nearer than before to the antennae, which have travelled by the opposite road.

The antennae themselves have undergone as profound a change in their structure as in their position ; in the larva they closely resemble the maxillae, being made up of a very few joints steadily decreasing in size, the penultimate bearing a long and simple bristle. In the perfect butterfly they are composed of a great number of joints which may be grouped into three parts—the base, the stalk, and the club ; the first two joints form the base, and differ from the remainder in their greater size ; most of the movements of the antennae are due to the freedom of motion of these basal joints ; the stalk is a mere jointed thread, and the club only an enlargement of the final joints, where they lose in length what they gain in thickness [Fig. 66] ; the extent and shape of this club vary widely among butterflies and often form a valuable guide to their real relationship. The antennae may be bare or they may be clothed to a greater or less extent with scales similar to those which cover the wings ; but in the latter case there is nearly always a naked space along the under surface, and particularly on the club, where it is provided with microscopic pits, connecting with delicate nerves, which are undoubtedly organs of sense, but whose use is not yet fully understood.

Fig. 66.—Club of antenna of Xanthidia Nicippe, × 25. The view is taken from the inner lower side.

Coming next to the mouth-parts of the butterfly, we shall find it difficult to believe that the wonderful apparatus by which the insect now procures its food in the depths of tubular flowers is simply a development of parts already in existence in an earlier stage, when by means of horny jaws it made such havoc among the leaves of its food-plant. The principal mouth-parts are a long, slender, flexible tube, rolled up precisely like a watch-spring; and, guarding it on either side, a large jointed appendage, densely clothed with scales and hairs, and often projecting forward or upward like feathery horns. No other parts are visible, and even when we remove these mufflers of the head, and expose all the parts about the mouth, we shall be puzzled to know what has become of the caterpillar's varied foraging paraphernalia. Its labrum was a swinging flap of membrane by which it appeared to force its food between its jaws; its biting mandibles massive horny plates with chiseled edges,

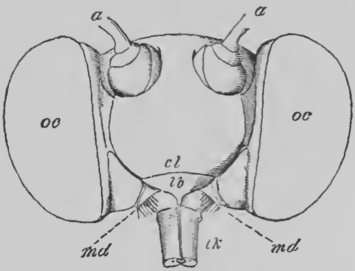


FIG. 67.—Front view of head of Danais Archippus, with the scales removed; *oc.* compound eyes; *a a*, base of antennae; *cl*, clypeus; *lb.* labrum; *md.* mandible, edged with bristles; *tk.* base of the maxillae or spiral tongue; × 10 (Burgess).

by means of which it nibbled the leaves; the former is now represented [Fig. 67] by a slight rounded immovable projection of the front, whose only office is to serve as a support to the base of the long spiral tongue; and the latter, the main agents of the caterpillar's work, are reduced to two little triangular projections, one on either side of the tongue; they are now soldered firmly to the head and remain as relics of a former stage. Rudimentary organs are by no means uncommon among animals, even where they never are of the slightest use to the creature during any portion of its present life. Viewed in the light of modern scientific investigation into the history and relationship of animals, we are quite justified in concluding that organs, having no full development and no present use, must in some past period have had their full part to play in the economy of the animal in which they are found. "Rudimentary organs," says Darwin,* "may be compared with the letters in a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a clue in seeking for its derivation." Such organs, therefore, possess the highest interest, and it was on this account that I felt justified on a preceding page in speculating on the possible meaning of the ocellar belt of the chrysalis.

From the mandibles we pass to the neighboring organs, the maxillae. In the larva, these parts consist, on either side, of a pair of appendages of simple structure, seated on a common hemispherical prominence and possessing only the power of withdrawal and protrusion ; the outer and larger consists of several joints ; the inner of only a

* Origin of Species, sixth ed., p. 402.

single joint, which becomes enormously developed in the butterfly to form a sucking organ of curious construction ; while the outer appendage becomes the maxillary palpus, reduced to a couple of minute joints or even less, only to be detected by the most careful observer, and physiologically null. As this sucking mouth is one of the most characteristic parts of the perfect butterfly, we will examine it more closely. Although almost

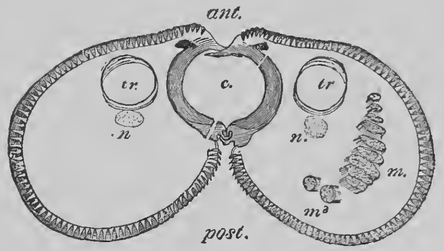


FIG. 68.—Cross-section of the maxillae or tongue of Danais Plexippus (the anterior portion uppermost) to show the mode in which the two halves unite to form a central canal (*c*); *tr*, tracheae; *n*, nerves ; *m*, m^2, muscles of one side; × about 125 (Burgess).

entirely concealed when coiled, it is frequently as long as the entire body, and consists of two lateral halves united down the middle ; each part is composed of an immense number of short, transverse rings, which are convex on the outer surface, concave on the inner [Fig. 68] ; and it is by the union of these inner concavities that a central tube is formed. The lateral rings are also partially hollow, and have, therefore, been supposed by some to form the sucking tube, in which case the insect might be said to have two mouths, for there would be two entrances to the oesophagus. This, however, is not the case, the interior of each lateral half being filled with muscles, tracheae, and nerves for the movement of the organ. The rings of which it is composed are made up of a great number of plates, united by the more yielding part of the cuticle, allowing of great freedom of motion. These rings throw off, at the points where the convex and concave sides meet, a series of oblique, curving plates or hooks, which, when the two maxillae are brought together, interlace in the most complete manner, to form a perfectly flexible yet impervious tube. The outer walls of the lateral tubes are supplied with curious papillae of greatly varying shapes, size, and abundance in different groups [see Figs. 178, 179], but, in general, more highly organized and abundant in the highest family. These must probably be regarded as organs of taste. Within either half of the maxillae, oblique muscles exist [Fig. 69] serving to coil the whole into the watch-spring-like form in which it is packed away when at rest.

But now that we comprehend the structure of this wonderful piece of mechanism, and can appreciate the change that has been wrought in its development from an utterly simple, almost microscopic joint, do we understand any better its actual use in extracting honey from flowers? Some have thought that the upward flow was due to capillary motion; some to the action of the so-called sucking stomach, a sac-like expansion of the alimentary canal just in advance of the true stomach; others that it is forced on by successive undulations and contractions of the tube itself. The investigations of one of our own naturalists* has, however, recently shown the existence of a muscular sac within the head [Fig. 70], at the origin of the alimentary tract, furnished with a valve at its front extremity where it opens into the maxillary canal. When the radiating muscles running from the walls of the head to the periphery of this sac are contracted [Fig. 71], the sac is opened, and into the vacuum thus produced the fluids into which the maxillae are plunged ascend. On the relaxa-

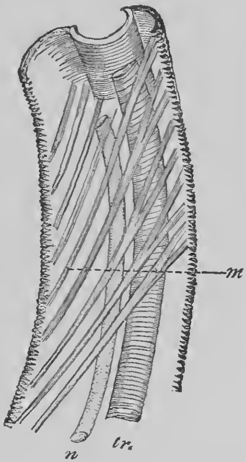


FIG. 69.—Longitudinal section of one maxilla of Danais Plexippus to show the interior muscles (*m*) which coil it and the nerve (*n*) and the trachea (*tr*) which pass through it; × about 125 (Burgess).

* E. Burgess, Amer. Nat., xiv., 313-319.

tion of these muscles and the squeezing of the sac by the muscles which encircle it, the fluids, prevented by the valve from retreating the way they came, are forced down the alimentary canal.

The only part of the head of which we have not spoken is the labium and its appendages; in the

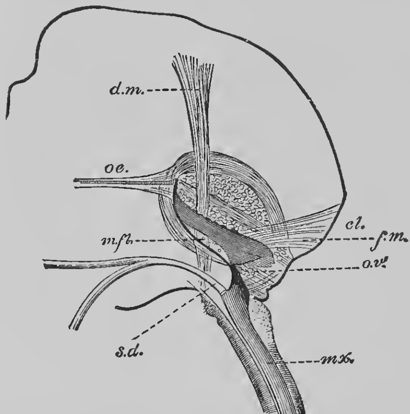


FIG. 70. — Longitudinal section of head of Danais Plexippus to show the pharyngeal sac; *mx*, left maxilla, the right being removed; *mfl*, floor of the mouth cavity or sac; *oe*, oesophagus; *ov*, oral valve; *sd*, salivary duct; *dm* and *fm*, dorsal and frontal muscles which open the sac; the cut ends of the transversely encircling muscles are seen above the sac, × 20 (Burgess).

larva these consisted of the spinneret, and on either side of it a minute jointed palpus like that of the maxillae. In the butterfly, the spinneret is gone, but the palpi have become developed into a three-jointed organ, often of considerable size, with inflated joints, all profusely clothed with scales and hairs, forming a bristling guard on either side of the face [see Fig. 65]. The size and relations of the different joints vary considerably in different groups; they may all be very small and look as if they were merely the scaly covering of the front of the face, or they may pro-

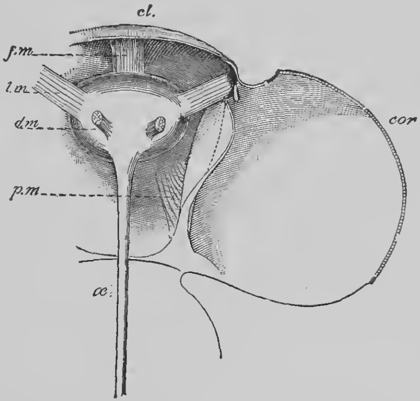


FIG. 71.—Interior view of the bottom of the head of Danais Plexippus to show the top of the pharyngeal sac and the muscles which distend it, × 16; *cl*, clypeus; *cor*, cornea of the eye; *oe*, oesophagus; the muscles are: *fm*, the frontal; *dm*, the dorsal, and *lm*, the lateral; *pm*, muscles moving the palpus (Burgess).

ject straight forward with a threatening aspect almost as far as the antennae.

We pass now to the middle region of the body, the thorax. Here the first segment, or prothorax, is reduced to a most insignificant part, and the only wonder is that it is capable of supporting a pair of legs, often as large as the others [Fig. 72]. The middle and hinder segments together form a compact vaulted oval mass, wholly concealed by scales and hairs, but divided by a number of sutures into the many parts which form the segments of the thorax. The middle segment, moreover, is developed to a far larger extent than the hindmost, in order to carry the front wings, which during flight are obliged to meet in great measure the resistance of the wind, and are therefore furnished with more muscles.

FIG. 72. — Prothorax and front of mesothorax of Vanessa Atalanta, with scales removed, × 2.

The appendages of the thorax are the legs, wings, and shoulder lappets. As in the earlier stages, a pair of legs is attached to each segment, but these legs are very different from the old appendages; they are now mere sticks, each divided into five principal pieces, called coxa, trochanter, femur, tibia, and tarsus. The coxae or haunches are often prominent, having the shape of pyramidal stems, more than half consolidated with the body and with each other, extending obliquely downward and backward, and forming in this way a strong support to the hinder part of the thorax, which is the real centre of gravity of the body. The trochanter is only a short joint between the haunches and the thighs, carrying the base of the latter a little outward and giving them greater freedom of motion. With the thighs, or femora, the principal part of the movable leg begins [see Figs. 172–177]; they are straight, long, and slender, perfectly simple in structure and clothed only with scales or hairs, the latter often forming fringes along the edge; in them lies most of the muscular mass of the legs; the tibiae or shanks are also straight, but much slenderer than the thighs and of about the same length; when the insect is resting or walking they are usually held at about right angles with the thighs; they are always scaled, and generally furnished throughout with one or two rows of spines, besides a pair of longer movable spines or spurs at the tip. In the lowest butterflies the front tibiae bear a slender leaf-like appendage projecting from the middle of the inner surface, and clothed with a velvety down [see Fig. 173]; its use or purport is wholly unknown, but its position reminds us of the extraordinary tympana on the front legs of crickets and long-horned grasshoppers, which are unquestionably organs of hearing and occur only in those groups which stridulate the loudest. The few butterflies, however, which are known to produce sounds belong to the highest family of Lepidoptera, in which this structure is totally absent; and whatever its use it is probably only a modified spur, such as is sometimes found on the hind shanks; certainly it originates at the same spot.

The tarsi, or feet, are normally composed of five joints, of which the first is usually as long as all the rest, and in the male is occasionally swollen; with this exception they are slenderer than the shank, and their combined length generally exceeds it [see Figs. 173–177]; they are scaled and more or less spiny like the shank, and a pair of the terminal spines of each joint usually exceed the others in length; the extremity of the last segment, however, is armed in a different way—by claws, paronychia, and foot pads; the claws are a pair of divergent curving hooks, each hook sometimes deeply cleft so as to be double; the paronychia, or whitlows, are curious membranous expansions, which almost encircle the base of the claws and are developed in various ways, at the sides, or beneath, into flexible imitations of them; sometimes they are wholly obliterated, but they are generally either absent or somewhat similarly developed in all the members of the same large group. The foot pads are fleshy membranous flaps, often pedunculated, attached to the base of the claws, and serving as soles for the feet; these, too, are sometimes wanting, especially where the paronychia are absent.

As a general rule the six legs are similar in structure and proportions; but further on [see

Figs. 174–177] I shall call attention to the curious fact that just as the first segment of the thorax becomes less and less developed as the insect changes from caterpillar to chrysalis and from chrysalis to imago, so, in passing from the lower to the higher groups, we shall find a gradual atrophy of the legs borne by the first segment of the thorax ; first, the different joints contract in size ; next, they lose a part of their armature ; then, adjoining parts become consolidated, until, finally, the tarsus forms only a single piece, spines, spurs, pad, paronychia, and claws all disappear, and the whole leg becomes so shrunken as to be utterly useless and readily overlooked ; practically, the animal has passed from a six-legged to a four-legged condition ; in this instance we can trace every step in the change ; and although, in the extremest case of atrophy, the front legs have not reached so low a stage as to be classed with wholly rudimentary organs, yet it is plain both that they are well on the way and that their original condition—that is, the condition of their ancestors—was one in which the front legs were fully developed, like the others. How far back in time this would lead us, we cannot guess ; the geological record now carries butterflies back toward the end of the lower tertiaries ; but some of the earliest fossil butterflies belong to the highest portion of the highest family, and are intimately allied to forms now living; portions only of the legs are preserved on such specimens as have been found; but while the evidence is certainly negative, it should at least be remarked that there is no indication that the condition of the fore-legs of these ancient creatures differed in any way from that of their allies of to-day; so we are forced to believe that in exploring the rocks we have not begun to reach the early forms of butterfly life.

We come now to the consideration of the wings of butterflies. Not to mention for the moment their exquisite beauty, they possess a deep interest in that they are totally new structures, and the first we have met in our review of the characteristics of the perfect insect. The parts we have before examined—tongue, palpi, eyes, antennae, legs—though very different indeed from the organs of the caterpillar, have nevertheless been represented in it by corresponding parts; while we should look there in vain for any external trace of wings. The mode of their origin we shall mention later, since, strange to say, it must be considered in treating of the internal parts; but the structure of the completed organ merits our closest attention.

The wings of butterflies, like those of all insects, are attached, one pair to the middle and the other to the hinder segment of the thorax, and consist of two membranes stretched upon a framework of tubular rods, which run between. In butterflies and moths, this framework and membrane are almost wholly concealed by a thick layer of minute scales, which overlie one another like slates on the roof of a house [Fig. 73]; this covering has gained for these insects the scientific name of Lepidoptera, or scaly-winged insects; and it is probably on account of this concealment that the mode of distribution of the rods forming the framework of the wing is one of the simplest among insects, although the butterflies themselves rank high in the order. Nature seems to sport with everything that is external, variety being the law as well as "the very spice of life;" for while the hidden and interior parts of the organization of animals differ in the main only as they affect or are affected by their habits and dire requirements, the outer parts are attired with a wanton display of luxurious color or graceful or even grotesque form and contour, which bewitch our senses, and, the naturalist in search of real affinities among animals would add, confuse our judgment; so while the colors and patterns

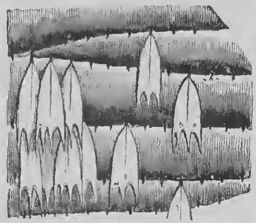


FIG. 73.—Arrangement of scales on wings of Lepidoptera, enlarged.

of a butterfly's wing beggar all description and outwit imagination, the framework of the gauze on which nature has set the mosaic is of the very simplest kind; in only one group (Heliconii) does it show any aberration and surprise us by odd turns and unexpected meanderings of the veins; and this is the one group of butterflies in whose wings we find large patches of membrane devoid of scales.

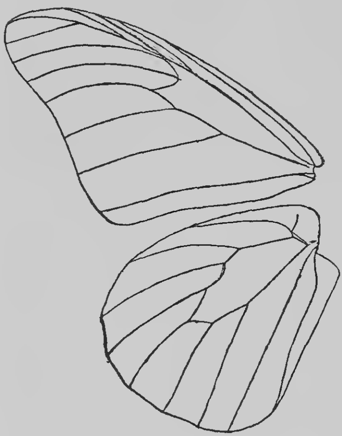


FIG. 74.—Veins of the wing in Danais Plexippus, nat. size.

The normal number of veins in the wings of insects is six, disposed to a certain extent in pairs [Fig. 74]; the middle pair usually branch to a greater extent than the others, and support most of the membrane of the wing. In butterflies the foremost vein is always absent, and very commonly also the hindmost, so that there are only five (often only four) principal veins, rather inappropriately designated costal, subcostal, median, submedian, and, when present, internal. The costal, submedian, and internal veins are invariably simple and terminate at the margin or even disappear before reaching it. The subcostal and median veins, on the other hand, are as invariably branched, and with their offshoots support nearly the entire wing [Fig. 75]; the subcostal vein curves downward and the median upward so as to meet, or nearly meet, about the middle of the wing, and to inclose between them a large space called the discoidal cell; all the branches of the median vein are thrown off from its lower side before union with the subcostal vein; the principal branches of the subcostal vein, on the other hand, are thrown off from its upper side [Fig. 76]; but as the vein curves downward at the extremity of the cell, another set is thrown off, at least in the front wings, from the lower side; and it is these branches, rather than the subcostal vein

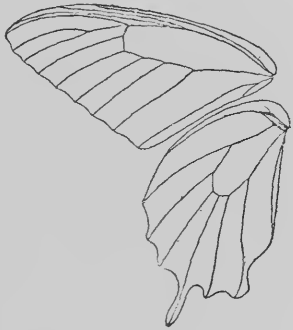


FIG. 75.—Veins of the wing in Laertias Philenor, nat. size.

FIG. 76.—Veins of the wing in Euphyes Metacomet, nat. size.

proper, which unite with the median vein to close the cell. None of the median nor any of the inferior subcostal branches are ever forked; but at the apex of the front wing, where the play of neuration is usually the greatest, the last superior subcostal branch is occasionally forked.

The neuration of the wings, then, consists of an upper and a lower (or two lower) simple straight veins, and a pair of middle veins which unite with or approach each other near the centre of the wing; and from the outer edge of the cell or loop thus formed throw off to the border a number of branches.

The wings of butterflies are very large in proportion to the body and are subtriangular in shape, particularly the front pair; here the broadest side is at the front, and is always more or less convex, and closely crowded with the strongest veins; just as in a bird or a bat the bones of the wings lie next the front margin, where the greatest resistance is required; in the hind wings of butterflies, where no such special resistance occurs, the veins are almost equally distributed, and the wing itself is of a more quadrangular shape, extending equally backward and outward, so as to bring the middle of the plane of the combined wings opposite the centre of gravity of the entire body.

At the base of the anterior margin of the fore wing is a horny scale, such as occurs in many other insects [see Fig. 72]. These scales improperly bear different names in different orders, and in butterflies are termed patagia or shoulder lappets; they protect the extreme base of the wing, and being attached to the body only at their front margin, are movable and do not interfere with the free action of the wing; being covered, like the thorax, with scales and hairs, they are noticeable only when these are removed, appearing in their natural condition to form a part of the solid body. Whether they should be considered as an element of the middle thoracic ring, or an appendage to the same, has not been proved; from analogy with other parts in the abdomen, it seems probable that, like the wings, being useful to the insect only in its perfect stage, they also are new structures, and not modifications of parts already existing in the caterpillar.

The only other point of interest in the thorax are the spiracles, of which there is only a single pair, opening upon the scaly membrane at the hind border of the front segment; as in the earlier stages, spiracles are wanting upon the middle and last segments of the thorax, where the wings occur. We shall again refer to this point.

About half the bulk of the butterfly's body is composed of the abdomen, though in the female when heavy with eggs it will often doubly outweigh the parts in front; externally, however, it is the least interesting part of the body. It is composed of eight simple rings covered with scales, variegated, if at all, only by stripes or series of dots, and bearing upon the sides of the first seven segments a pair of spiracles entirely concealed by scales. As in other insects, one finds at the extremity pieces of very variable construction, which here, more perhaps than elsewhere, have the appearance of forming parts of still other rings; they are, however, only appendages of the last and the penultimate segments; this is proved by what is known of their origin and mode of growth in other insects, where they often have an extraordinary development, as ovipositors or stings in one sex or as nippers in the other. They are entirely new structures, arising in the pupal stage, first as mere tubercles, then as outgrowths from the inferior plates of the body, but afterward becoming attached to various portions of the last two segments, in such a way as to allow them a certain freedom of motion, and often

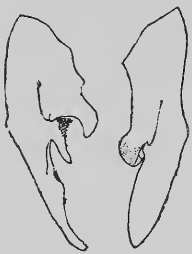


FIG. 77. — Asymmetrical appendages of the right and left sides of the abdomen in Thanaos Ennius, × 10.

to obscure their real origin. In certain male butterflies these parts are asymmetrical [Fig. 77], that is, they are not altogether similar in appearance upon the two sides, a phenomenon difficult of explanation.

CHAPTER V.

INTERNAL ORGANS.

We have now discussed the salient points of the external structure of caterpillars, chrysalids, and butterflies. We shall not consider their internal organs at such length, partly because they cannot in themselves possess so great a general interest, and also because they have not yet been sufficiently studied to enable one to present a detailed and impartial review. After a short survey in this chapter of their peculiarities in the caterpillar, we shall turn at once to their appearance in the butterfly, and trace one by one the steps by which the changes are effected.

In considering the external crust of the animal and its appendages, we have been able by its very organization to examine each part separately without confusion ; and even to recur readily to its characteristics when we afterward wished to follow its development ; for, by the division of the body into distinct regions, and of the regions into separate rings, each bearing its special appendages, the mind could readily locate these and recall them when necessary. When, however, we come to the internal parts, the case is generally different; for the organs run in a longitudinal course through the body and disregard in great measure not only the jointed structure but even the regional distinctions of the body. To systematize our examination, therefore, we must treat them differently, and separating them into natural subdivisions according to their functions discuss them in that sequence which promises to give us the clearest conception of their use.

As the basis of the whole, we have the structural framework of the animal, its outer crust; and since power of movement is the primal need of a living creature, we shall first consider the muscular system, through which the framework and its appendages are moved; next we will take up the digestive system, the province of which is to prepare crude nutriment for the insect; the further preparation of this nutriment by oxygenation requires that we should follow with the respiratory system; and the distribution of the nutriment over the body by the circulatory system completes the circuit of the relation of food to the creature; but whether the natural action of these systems be voluntary, as in the first mentioned, partly voluntary and partly involuntary, as in the second, or wholly involuntary, as in the last two, they all require to be brought into relation to the will of the animal, or their vital action ceases; we therefore consider next the nervous system, the seat of volition and sensation. In discussing the earlier stages of the insect, we shall next take up the glandular or secretory system, since its sole independent representative is the organ which serves to secrete silk, by means of which the caterpillar is able to walk where it needs to procure nourishment. These are all the systems which have to do simply with the life of the individual, but there is still another, the reproductive, which must take the highest place as related to the life of the species ; in the caterpillar this remains in an embryonic condition, a condition of preparation for future development ; and finally we shall consider briefly the cellular system, which is almost entirely confined to the larval stage and is intimately related to all the other systems.

The celebrated Lyonet counted more than four thousand distinct muscles in a single caterpillar, but we will admire his wonderful patience only at a distance, and merely remark that the muscular system of caterpillars consists almost entirely of flat ribbons, made up of simple muscular fibre. The head, however, with its numerous movable organs, forms a partial exception, for it is mostly filled with conical muscular bundles, lying in a compact mass side by side, with their smaller ends attached to the mandibles by means of a tendinous cord in which they all terminate, and their base to the walls of the head, especially the posterior portion, which is quite crowded with them ; these muscles serve to draw the jaws together ; and since most of a caterpillar's time is spent in feeding, their monopoly of the head-cavity is explained. In the body, the riband-like character of the muscles is fully developed, but the continuity of the ribands is constantly broken, for no one muscle ever crosses more than two contiguous segments ; generally they pass from the hinder end of one to the hinder end of the next ; this accounts for the vast number counted by Lyonet, and is incident to the jointed character of the body, which, as we have said, lies at the very foundation of its structure. These muscles may be divided into three classes—longitudinal, oblique, and transverse ; the longitudinal bands are made up of short muscles, each a segment in length, lying end to end, so as to give the effect of long ribands, extending the whole length of the body ; there are several such bands, each of considerable width, and they form the inner wall of the body. Just beneath them lie the oblique muscles, which always extend from the hinder end of one segment to the hinder end of the next, and are found mostly upon the sides. The transverse muscles lie next the skin, are mostly confined to the sides, and those of one segment are entirely independent of those of any other; these are brought into use principally at the time of moulting. In the legs and prolegs the walls are coated with short muscular ribands, uniting the hinder portions of contiguous joints, a miniature of the longitudinal muscles of the body; but besides these, a tendinous cord runs through the middle of the true legs, attached at one extremity to the claw, and connected throughout with muscles running obliquely to the walls of the leg.

The digestive system consists of an alimentary canal with anterior and posterior appendages; the canal is a simple, cylindrical, muscular tube extending in a straight line from one end of the body to the other, enlarging in certain places and contracting in others, so that it may be divided very naturally into an oesophagus, a stomach, and an intestine. The oesophagus is a simple slender tube, enlarging to a sort of crop near the middle of the thoracic joints; the stomach is a much larger tube, of uniform size, extending nearly to the extremity of the body and covered with muscular threads, which run transversely, diagonally, and longitudinally; at about the seventh abdominal segment this tube suddenly contracts, and opens by a slender orifice to the intestine, the anterior half of which is tightly wrapped in strong muscular fibre, running in various directions, so as to mould the interior walls into prominent longitudinal ridges; while the posterior half, or colon, is smoother and less muscular within [Fig. 78].

The anterior appendages to the intestinal canal are a pair of salivary glands, little white threads having their origin near the commencement of the oesophagus, and running along this nearly to the stomach. The posterior appendages are a pair of malpighian vessels, also composed of exceedingly long slender threads; they originate on each side of the intestine, and very soon subdivide into three tortuous branches, which pass forward and backward along the walls of the stomach, and finally, returning to the point from which they started, cover the intestine with a most intricate mass of convoluted threads.

The respiratory system consists of a series of air-tubes ramifying indefinitely, each set of which originates in a single trunk, opening from one of the numerous spiracles or breathing pores with which we have found the insect provided; close to the origin of this trunk a large air-canal runs along the sides of the body, connecting all the trunks of one side, while other shoots originate from the canal itself; and, indeed, as it passes through the second and third thoracic segments, which, as already stated, possess no spiracles, this canal emits large branching trunks just like those of the other segments, directly opposite the

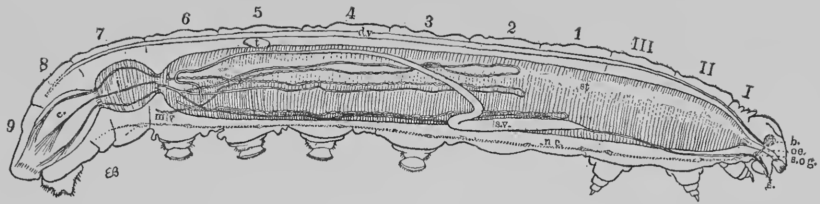


FIG. 78.—Longitudinal section through the larva of Danais Plexippus ♂ to show the internal anatomy; the Roman numerals indicate the thoracic, the Arabic the abdominal segments; *b*, brain; *sog*, suboesophageal ganglion; *nc*, nervous cord; *oe*, oesophagus; *st*, stomach; *i*, intestine; *c*, colon; *sv*, spinning vessel of one side; *s*, spinneret; *mv*, malpighian vessel, of which only the portions lying on the stomach are shown, and not the multitudinous convolutions on the intestine; *t*, testis; *dv*, dorsal vessel; the salivary glands are not shown. × 3. (Burgess.)

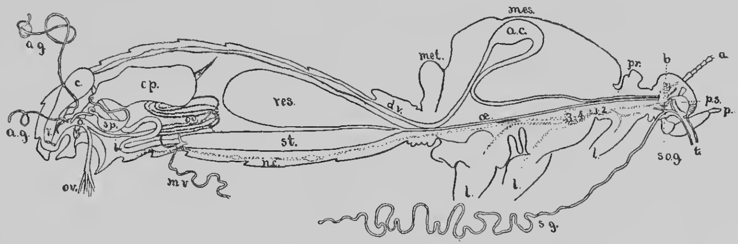


FIG. 79.—Longitudinal section through the imago of Danais Plexippus ♀ to show the internal anatomy; *t*, tongue; *p*, palpus; *a*, antenna; *pr*, prothorax; *mes*, mesothorax; *met*, metathorax; *ps*, pharyngeal sac; *b*, brain; *sog*, suboesophageal ganglion; 1-2, blended first and second ganglia of the larva; 3-4, blended third and fourth ganglia of the larva; *l*, *l*, *l*. the three legs; *ac*, aortal chamber; *dv*, dorsal vessel; *oe*, oesophagus; *res*, reservoir for air or food; *st*, stomach; *mv*, malpighian vessels; *i*, intestine; *c*, colon; *r*, rectum; *cp*, copulatory pouch; *o*, oviduct; *ag*, accessory glands; *sp*, spermatheca; *ov*, ovaries (not fully developed); *nc*, nervous cord. × 3. (Burgess.)

spots where one would look for spiracles; it even sends a small tube from opposite the base of each trunk to the point where the neighboring spiracles should be, which, however, disappears with the growth of the animal. Indeed, we may reasonably believe that in the original form of the larva it possessed complete breathing organs upon these segments, since they differ from the succeeding segments only in the want of spiracles and in the slightly smaller size of the tracheal mass, and of the exceedingly short tube which connects it with the spiracles.

These air tubes ramify and subdivide infinitely; a great many of them impinge upon the stomach and encircle it in their grasp, serving in fact as its support; others penetrate all parts of the muscular mass, embrace every organ and track along every thread of nerve or fibre; those from the first segment behind the head, after first uniting with each other so as to make a perfect communication between the tracheae of the two sides of the body, send powerful branches from the point of union into every part of the head, where the minute subdivisions pass into the furthermost joints of the antennae, or into the jaws, while every muscle finds one for its nearest neighbor.

It is not, however, until we come to consider the circulatory system that we can fully understand the meaning of this endless ramification of the tracheae, for it almost forms an integral part of that system. The centre of circulation is what is known as the dorsal vessel, a straight tube lying along the back directly beneath the skin. This can often be seen through the transparent skin, but on dissection it is very difficult to recognize its true structure, so excessively delicate and vague are its bounding walls; it appears more like a passage-way between other bodies than as a distinct vessel; and indeed it is often only by tracing its development up to the perfect insect that its actual structure can be clearly determined. The dorsal vessel is open posteriorly and is also furnished along its sides with valves opening inward and directed forward; the alternate contraction and expansion of the vessel forces the fluids of the body through these openings and along the canal toward the head; here the vessel becomes very slender, with more distinct walls, but at the extreme front of the head, near the base of the oesophagus, it terminates, and the fluids enter the general cavity of the body to flow gently to the opposite extremity, and there to be pumped again into the dorsal vessel.

To understand, however, how oxygenation is effected, we must glance once more at the tracheal tubes. These are really involutions of the external integument of the insect; the outer chitinous coat (now become the interior lining) is curiously modified, however, to form a continuous, closely coiled, spiral thread, making an elastic cylinder; this does not continue throughout the entire trachea, but disappears when the finer ramifications are reached, leaving only the softer epidermal integuments; these apical portions of the tracheal vessels, as has been said, are found everywhere, piercing the fatty lobules, clasping all the interior organs, tracking along every nerve and muscular fibre, penetrating every tissue, and terminating in a mesh-work of interlacing branches, their surfaces everywhere bathed in the fluids which fill the body cavity and flow gently from head to tail by the pulsatory action of the dorsal vessel. Oxygenation, then, is effected by the interchange of gases through the delicate membranes investing the ultimate tracheal branches, and when effected the purified fluids are at hand to build up the tissues of the body, and have not to be forced to the needed spot by arteries.

The foundation of the nervous system of caterpillars is a series of minute horizontal disks or ganglia lying on the floor of the body cavity along the middle line, and connected with one another by a pair of slender cords, lying side by side; as this series of disks and connecting cords enters the head, it forms a ganglion just beneath the oesophagus, beyond which the cords embrace the oesophagus, and again unite above in a pair of large globular lobes, which constitute the brain; in front of these are one or two other exceedingly minute disks, similarly connected, called the frontal ganglia. From either side of the brain three principal nervous cords are emitted, one to the ocelli, one to the antennae, and one to the base of the tendinous cord which connects the principal muscles of the head with the mandibles; the one passing to the ocelli is the largest, tapers until it approaches them, and then expands over a broad area inclosing them all.

Theoretically there is one ganglion to each segment of the body; but when we reach the seventh abdominal segment there are two, one close behind the other, and in the succeeding segments none at all; the hinder and slightly larger one in fact represents the combined ganglia of the posterior segments, and from it the nervous threads pass to the very extremity of the body. At the sides of all the ganglia, and from the nervous cord just in advance of each ganglion, lateral threads are emitted and pass outward toward the walls of the body, branching in every direction, covering each organ and muscle with filaments of nervous tissue; there are two of these principal branching threads on either side of each ganglion, the anterior generally feeding the upper and the posterior the lower half of the body.

The only organs of special secretion in caterpillars are the silk-vessels ; these have a distinct outlet on the under lip, which becomes modified to form a spinneret ; from this point a delicate thread runs along the oesophagus to the middle or end of the thoracic part of the body ; there it thickens to form the secreting vessel, a slender flattened riband, running in the same direction along the sides of the alimentary canal to about the middle of the stomach, when it turns a little upon its course, again reverses its direction, and passing above the stomach, continues to its extremity.

Finally the reproductive system, which relates to the species rather than to the individual, is of extreme simplicity ; it consists mainly of a pair of very minute bodies, either a chambered gland or a consolidated bunch of tubes, forming a sort of sac ; these bodies are situated on either side of the fifth abdominal segment ; from each of them proceeds a thread which runs back a little way, and then down and back along the sides of the body until it has nearly reached the middle line beneath, when it passes through a special band of muscle, and, side by side with its mate, terminates in a common blind sac, situated just beneath the extremity of the intestinal canal.

The nutriment received into the body is not all absorbed by the formation and continual repair of organs and muscular tissue ; and when the supply is greater than the need, the residue is stored in cellular tissue, to be used at a fixed epoch of the caterpillar's life, when its continued existence depends upon this reserve force. On opening the body, we find a great quantity of fatty matter, in continuous layers of convoluted lobules, strapped down by the muscles between which it has penetrated, enwrapping the whole intestinal canal, and filling every space that can be found between the different organs of the body.

This explains the voracity of the caterpillar, and shows that the main end of its existence is to gormandize and grow ; examining its interior, we find that the muscles occupy hardly more space than twice the thickness of the skin to which they are attached ; and their very object is to move the creature to a feeding spot or remove the old integument to admit of a larger growth and a greater capacity for food ; those of the head are almost exclusively attached to the jaws. The general cavity of the body is mostly occupied by the alimentary canal and its appendages, the glands and nerves and even the tracheae really requiring an insignificant amount of space ; and whatever is not occupied by these organs, necessary to the assimilation of food, is choked up with the fatty masses embedded in the cellular tissne.

CHAPTER VI.

TRANSFORMATIONS OF THE INTERNAL ORGANS.

LET us now look at the changes which the internal parts undergo, as the caterpillar passes through the chrysalis to the imago state.

To begin with the muscular system, we find the principal differences between the caterpillar and imago to exist in the head and thorax ; in the abdomen the muscles moving the different joints are much the same, although greatly reduced in size ; the interior of the head, however, presents a very different appearance ; instead of being mainly occupied by muscles moving the horny jaws, the space is nearly all given to brain and optic nerve, and what few muscles there are serve simply to move the antennae, the tongue, and the labial palpi, and to open and close the pharyngeal sac ; these have been developed at the expense of the muscles of the mandibles, which, from occupying nearly the whole head, have almost absolutely disappeared, since the mandibles are now immovably soldered to the frame-work of the head. The thorax is greatly swollen and the longitudinal muscles, instead of merely lining the skin, have increased so as to fill more than half of the interior ; the oblique muscles occupy almost all the rest, and both sets retain nearly the same direction as in the larva. These muscular bundles, through which the alimentary canal, the dorsal vessel, and the nervous cord seem now scarcely able to find passage, are the muscles of flight ; and yet they touch neither the wings nor their attachments. The flight of butterflies is mainly effected simply by changes in the form of the thorax, produced by the contraction of one or the other set of muscles ; the longitudinal muscles, which are the more voluminous, serving to shorten and elevate the thorax, and so depress the wings, while the oblique muscles serve to lengthen and depress the thorax and elevate the wings. The changes that have occurred in the muscular system are due to degeneration and reorganization during pupal life ; even where, as in the longitudinal muscles of the thorax, the direction is the same, it should be noticed that they now reach across the second and third thoracic segments without interruption, whereas in the caterpillar they were formed of distinct muscles, each of which crossed only a single segment, though with contiguous ends.

Transformations have also occurred in the digestive system, and these changes commence in the very earliest stages of pupal life and continue throughout that period; there is no sign whatever of any approaching change, so long as the caterpillar continues to feed; but when it has attained maturity in this stage, the entire contents of the alimentary canal are voided, and from this moment the form and relations of the parts begin to change and new parts arise; first, the whole canal becomes more slender, a natural result of its emptiness; then the oesophagus and intestine lengthen, at the expense of the stomach, which tapers at either end; next, the oesophagus swells just at the entrance of the stomach, and the colon, which has retained a globular form while the intestine grew slender, begins to turn a little from a direct course; the malpighian vessels, too, formerly attached to the middle of the intestine, often begin to approach the extremity of the stomach; and when they have finally reached it, perhaps only a week after the caterpillar has changed to chrysalis, the little swelling at the end of the oesophagus has grown to a bladder with a minute orifice, and is destined to be at least half as large as the stomach itself upon which it lies; at the same time, the colon has grown asymmetrical and developed a coecum upon one side. After this, the intestine begins to lengthen and grow tortuous, until, at last, the alimentary tract is often twice as long as the body. The little bladder at the end of the oesophagus has been considered by most authors as a pumping stomach, by the exhaustion of which the fluids pass up the spiral tongue; but we have found that other organs exist sufficient for this purpose, and it seems more probable that it is either a simple air vesicle, rendering the insect more buoyant, or a food reservoir, wherein to store and digest at leisure the honeyed sweets obtained on a sunny day. The salivary glands and malpighian vessels do not greatly change in character during the growth of the insect [Fig. 79, on page 82].

The respiratory and circulatory systems differ so little in the larval and perfect stages of butterflies that it is not worth while to dwell upon them. It may simply be remarked with reference to the latter that the dorsal vessel has (1) become less vague, with well-defined vascular walls and regular and considerable periodic enlargements; and that (2) in the thorax it does not follow the superior wall of the body throughout, but near the middle, where it enlarges considerably, it returns upon itself, plunging downward and backward through the mass of muscles which fill the chest until it has nearly gained the point at which it entered the thorax; when it turns once more toward the head and passes to it in a nearly straight course.

The nervous system has greatly altered, although its general course and structure remain the same. Instead of being almost equally distributed in every segment of the body, the greater proportion of it is removed forward and concentrated in the head and thorax; the principal changes are the following: the brain increases steadily in size, the little ganglion beneath the oesophagus approaches it as closely as the attenuating oesophagus allows, the cords which connect it with the first body-ganglion shorten, then broaden so as to obliterate the former, and finally lengthen so as to separate the two by more than their former distance; the first and second ganglia of the body approach each other until they fairly melt in one, the connecting cords becoming more and more divergent and then approximating until they, too, merge in the general mass; the third and fourth, that is, the last thoracic and first abdominal ganglia, act in a similar way toward each other, and at the same time approach the united first and second until they are separated only by short and thick commissures, and together form a thoracic mass, nearly equal to that of the head; it will be noticed that one of the abdominal ganglia has, therefore, entered the thorax. With the shortening body of the insect, the ganglia behind in like manner approach each other, the uniting cords not diverging but becoming sinuate, and regaining their former straightness only after most of the changes incident to this stage of the animal's life are consummated; the fifth and sixth ganglia gradually disappear, so that a long distance now intervenes between the thoracic and abdominal ganglia, and those of the latter region are no longer placed in the respective segments in which they first appeared. Many of the nervous threads have in like manner become amalgamated, and in all cases they have been transported with the ganglia from which they originated, or they issue from the main nervous cord at the points where the ganglia have vanished.

But it is in the reproductive system that the greatest transitions occur. The little sac and thread on either side of the body, without outlet, and only to be traced with difficulty in the caterpillar, have come to fill nearly the entire abdominal cavity of the perfect insect. In one sex, the little sacs first approach each other upon the back and then increase in size and amalgamate in one spherical body; simultaneously with its increase in size, the threads enlarge and lengthen, and with their inextricable convolutions fill the whole abdomen, and find their outlet next that of the alimentary canal. In the other sex, the little tubes of which the sac is composed separate excepting at the tip, increase wonderfully in size and length, coil up and become distended with eggs, finally weighting the body to such a degree that the butterfly flies with difficulty; while the thread has enlarged and here and there developed special vessels, just as we have seen in the alimentary canal; so that at last it would scarcely seem possible that so complicated a system could have arisen from a simple thread.

Finally, the silk vessels of the caterpillar have entirely vanished before half the pupal stage is past, and the immense material stored in the cellular system has become absorbed by the requirements of the rapidly growing organs until scarcely a trace is left. Thus we see that revolutions have occurred within the body quite as great as those of the external envelope, and these changes have mostly transpired during the earlier stages of pupal life, or in the day or two which precede and follow the absolute change from larva to chrysalis.

There are certain organs of the butterfly which, as we have said, are not mere alterations or outgrowths of parts previously existing, but new structures, each of which has its own proper development; we will briefly consider the most interesting of these, the wings.

FIG. 80.—Wing of Hamadryas Io, as it appears in the interior of the full-grown caterpillar; × 4.

If we were to open a fully grown caterpillar, we should discover [Fig. 80] upon either side of the last two thoracic segments a lustrous, translucent, circular pad, attached to the inner walls of the body and directed upward; these pads closely resemble the flakes of fat in the same vicinity, and, like them, are permeated by the minuter extremities of tracheal vessels ; their point of attachment is just above and slightly in advance of the spot where the spiracle should be ; they are fed by delicate nerves and by tracheal vessels, from the latter of which the permeating threads arise ; but they do not originate, as Landois asserts, from the longitudinal tracheae themselves, but from the hypoderm or inner integument of the creature, as Lyonet described it more than a century ago, Herold sixty years since, and Dewitz, Ganin, Graber, and others have latterly clearly shown. These pads, which really originate in the earliest stage of the larva, but are not then readily detected, are compressed folds of the hypoderm, which do not protrude externally like the other appendages of the body, because they form infolded pockets beneath the outer chitinous covering of the caterpillar ; they resemble the half reversed finger of a glove, so withdrawn that the tip of the finger is on a level with the base. Shortly before pupation, the tip begins to push its way outward beneath the chitinous skin, a condition indicated by the swollen sides of the caterpillar at that point, so as to become actually rather than potentially external appendages of the hypoderm ; and when the larval skin is removed by pupation, they are for the first time exposed to the eye.

CHAPTER VII.

HABITS.

In the preceding chapters we have discussed the external frame-work and the internal organization of butterflies. We now leave these rather dry details, and proceed to a more interesting topic, the Life of butterflies. Here, as in the lives of men, we shall find that "all the world's a stage," and in this moving drama of life shall discern the same struggles for existence, the same survival of the fittest, although not the exhibition of such varied passions, as in human history. We shall see how the diverse relations of butterflies to their environment are proofs of the moulding power of these unseen forces. That this should be so is hardly surprising when we consider that they are openly exposed to all the varied influences of their surroundings under four entirely different structural forms; and that although they are active in only two of these, yet they then differ so widely in both life and organization that, if the relation between them had never been traced, it could never have been surmised. So far, therefore, as their lives are concerned, we must treat the caterpillar and the butterfly much as if they were beings as distinct as they appear ; indeed, the only connection one has with the other seems to be in the care which the mother butterfly exercises in laying the eggs from which the caterpillar is one day to creep ; and since in most instances this stands in direct relation to the life of the caterpillar, we will commence our account with this point, and illustrate it, as we shall all our future discussions, mainly from the butterflies of our Northern States.

The butterfly generally lays her eggs singly, although some species deposit in small clusters and others again in great masses. These eggs are laid on the food-plant of the caterpillar, unless indeed the caterpillar feeds on grasses or other common herbage, when the eggs are laid indifferently upon objects near the ground, or, as I believe, in one instance (the White Mountain butterfly, Oeneis semidea), are dropped loosely upon the soil in the midst of the herbage. The Camberwell Beauty (Papilio Antiopa) chooses in the spring-time the terminal shoot of a willow or elm, and, perching head downward, with closed wings, deposits a dozen or more pale yellow ribbed eggs in a little girdle around the twig, next the petiole of the springing leaf [Fig. 81]. The

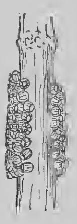


Fig. 81.—Clusters of eggs of Papilio Antiopa, encircling the twig of an elm ; × 2.

Baltimore (Euphydryas Phaeton) searches the swamps for the snake-head, and lays upon the under surface of the broad leaf a mass of hundreds of eggs [see Fig. 15], piled in several layers. Our Nettle Tortoise-shell (Aglais Milberti) lays its eggs upon the under surface of the leaves of nettles, generally between the principal veins, but often covering some of these, in large, irregular, partly open patches, in which the eggs are rarely if ever piled upon one another [Fig. 82]; sometimes several patches may be found upon the same leaf.

Fig. 82.—Clusters of eggs of Aglais Milberti, on the under side of a nettle-leaf, nat. size.

The Blue Swallow-tail (Laertias Philenor), partial to aristolochia, fastens on that plant and its allies some six or eight eggs side by side in two or three short rows; and I have twice found upon the under surface of nettle-leaves a hanging column of from three to nine glistening eggs of the Orange Comma (Polygonia Comma) placed end to end [Fig. 83]. The Banded Purple (Basilarchia Arthemis)

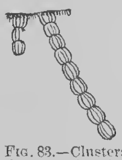


Fig. 83.—Clusters of eggs of Polygonia Comma, on the under surface of a nettle-leaf; × 3.

of the hilly parts of New England prefers the cherry birch, and glues a single egg upon the upper surface of the leaf at its extreme tip. Similar although even more extraordinary is the place chosen by its cousin, the Red-spotted Purple (Basilarchia Astyanax), which selects the extreme tip of the trembling aspen-leaf, which tapers delicately to a very fine point; in both these cases, the insect usually deposits but one egg on a tree. The Tiger Swallow-tail (Jasoniades Glaucus) [see Fig. 6] shows similar care with birches; while the Gray-veined White (Pieris oleracea) [see Fig. 10] and the imported cabbage butterfly (Pieris rapae) dot the surface of our turnips and cabbages with pyramidal eggs. In all these cases, the caterpillar feeds upon the plant which the parent has selected; yet she seldom can see, certainly never has been known by the slightest sign to recognize, the young for whose sustenance she is at such pains to provide. This is one of the wonders and perplexities of instinctive action. Let us take, for example, the Viceroy (Basilarchia Archippus), which during its butterfly life has never tasted, can by no possibility ever taste, of willow or poplar; that it should choose just these trees necessary for the food of progeny it is never to see defies our powers of explanation on any hypothesis which leaves all to blind forces.

The growth of the embryo within the egg is rapid, so that it sometimes hatches in a few days, although some eggs endure throughout a winter and hatch in the spring. Each, however, has its appointed time within very narrow limits ; and when the time of birth arrives, the little prisoner has but to move his jaws, already in contact with the egg-shell, to bite a hole through it for his escape ; often he bites a slit around the summit of the egg, and, pushing up the lid thus formed, takes his departure. The taste he has gained of egg-shell seems to allure him ; for, strange as it may seem, although placed by the provident parent within immediate reach of choice and succulent food, he will not taste it until he has devoured the last remnant of his prison-walls. Strange food this for a new-born babe ! The act, however, is plainly a provision of nature by which the tender animal is rid of a sure token to his enemies of his immediate proximity. Yet whence did he learn his lesson, perched quite by himself, maybe, as in the case of the Viceroy's caterpillar, upon the outmost twig of a poplar, out of sight of a solitary companion ? Is this reason or instinct ? and if instinct, will those who believe this power to be only an accumulated inheritance of ancestral wisdom pray give us a single suggestion of the line of descent by which this lonely, defenceless creature learned *his* art ?

Let us follow the history of the Viceroy [Fig. 84] a little farther. Born upon the extreme tip

FIG. 84.—Basilarchia Archippus, nat. size; the under surface of the wings is shown on the right side, the upper on the left (Harris).

of a trembling leaf, its prison-walls demolished, it begins to devour in a curious manner the leaf on which it rests; it nibbles away either side of the tip, leaving the midrib untouched [Figs. 85–87]; each time it has finished a repast, it retires to this midrib [Fig. 85] to digest the meal, where, facing outward with head bent to the ground, it rests immovable; appetite returning, it wheels about, hurries to its old feeding-spot, and, its meal finished, retires again to its accus-

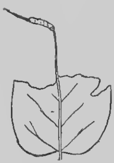


FIG. 85.—Leaf eaten by Basilarchia Archippus, with the caterpillar resting on the bare midrib after a meal; nat. size.

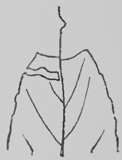


FIG 86.—Leaf eaten by caterpillar of Basilarchia Archippus; nat. size.

tomed station for a new siesta. A similar habit has been observed by Riley in the young caterpillar of the Goatweed butterfly, which in after-life lives in a nest formed of a single leaf [see Fig. 97], somewhat resembling, on a large scale, the hibernaculum of the Viceroy; it "invariably commences feeding at the tip of a leaf, stripping it down the midrib, upon which, between meals, it rests exposed" [Fig. 88]. This is the more remarkable because Riley states that several eggs are sometimes laid upon a single leaf; in such a case, the caterpillars must disperse on hatching, as even two could scarcely follow this mode of life very conveniently upon the same leaf. The caterpillar of the Viceroy signifies its displeasure at any disturbance by tossing the head upward, scraping its jaws at the same time upon the leaf; when moving about, it walks with a palsied shake of the whole body which is ludicrous to see. It remains

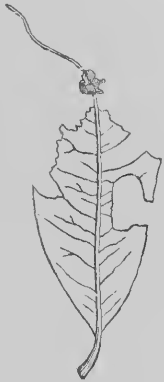


FIG. 87.—Leaf of willow eaten by the caterpillar of Basilarchia Archippus, showing its habit of leaving a little lump of débris attached by silk to the midrib; nat. size (Riley).

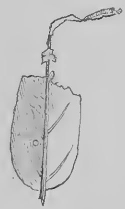


FIG. 88.—Young caterpillar of Anaea Andria, seated on the extremity of the stripped midrib of a leaf of goatweed; nat. size (Riley).

on this one leaf until it is entirely devoured ; then it betakes itself to the next leaf upon the twig, and so on in succession until the stem is bare, by which time it has reached maturity ; after it has left the first leaf, however, it is by no means so particular to commence feeding upon the tip, but cuts large pieces anywhere and quite irregularly, biting through the midrib as well as the rest of the leaf, and retires to the stem of the twig to digest its meal.

This caterpillar, as well as many others, lives a solitary life ; but there are those which are more or less gregarious, and they belong for the most part to the higher groups. Whenever the caterpillars are strictly gregarious, the eggs are invariably laid in clusters ; there are, however, some butterflies which lay their eggs in small clusters, whose caterpillars are not properly gregarious ; yet all such are closely related to others whose caterpillars are gregarious, so that we find every gradation from solitary to social. There are also some caterpillars, like those of our Baltimore of the swamps, which are gregarious in their early life, but afterward part company. In such cases, the caterpillar usually hibernates, and its social life lasts throughout the autumn and winter, the company dispersing at the renewal of activity in the spring. Indeed, in almost all cases, the association is most conspicuous in early life, when the caterpillars feed in rows upon the same leaf in such close proximity that it would seem to interfere with convenience. Sometimes this is the only mark of their social nature ; but as all caterpillars spin more or less silk in moving about, a web of greater or less extent generally accompanies a colony, and in some cases the community constructs a close structure, like that woven by the Baltimore [Fig. 89], the caterpillars of which in-

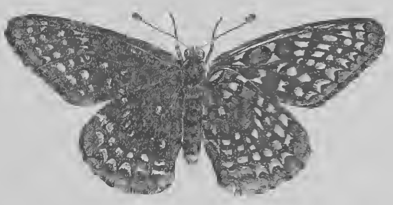


Fig. 89.—Euphydryas Phaeton, nat. size ; under surface on right (Harris).

close the whole tip of the plant on which the company feeds with a dense web [Fig. 90], within which they retire to rest or to moult. A Mexican butterfly, allied to our sulphurs, constructs a web, first noticed by Hardy,* which is nearly as close as parchment. With rare exceptions, all butterfly caterpillars feed upon the outside of plants ; but there are a few which live in the interior, and one of these, an Indian species, is known to be social,

* Travels in the Interior of Mexico. See also Westwood, Trans. Ent. Soc. London, i., 38 (1834).

living in numbers within the fruit of the pomegranate.*

The construction of nests for concealment is not confined to the social caterpillars, but extends to

FIG. 90.—Web-nest of caterpillar of Euphydryas Phaeton, half nat. size. (Copied from Edwards.)

a large number of solitary species. I am inclined to believe the habit universal among the skippers, or lowest family of butterflies. Some of them live in the interior of stems of living plants;

* Trans. Ent. Soc. London, ii., 1 (1837).

others in slight nests formed by weaving together several upright blades of grass: others, and these are generally some of the larger species, like the White spotted Skipper [Figs. 91–93], draw several leaves together just as they grow upon the plant, and, retaining them in the desired place by silken bands, live within the leafy bower. In earlier life, these same caterpillars, as well as the full-grown caterpillars of other species, construct nests by folding over a little piece of leaf,

FIG. 91.—Nest of caterpillar of Epargyreus Tityrus, nat. size. (After Riley.)

and fastening the edge to the opposite surface by a few loose strands of silk [Fig. 94]; to effect this they first bite a little channel into the leaf

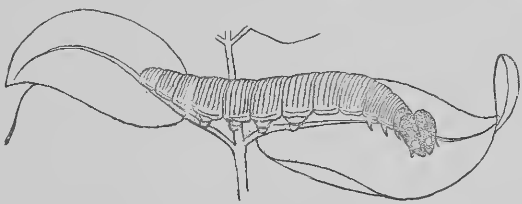


FIG. 92.—Caterpillar of Epargyreus Tityrus, nat. size. (After Riley.)

at just such a place as to leave a fragment of leaf neither too large nor too small to serve as a roof when they shall have turned it over; often they have to cut two channels in order to procure a flap sufficiently small for their purposes; and it is curious to watch one of these tender creatures, just as soon as it has devoured its egg-shell, struggling with a tough oak-leaf, to build for itself a house.

Fig. 93.—Chrysalis of Epargyreus Tityrus, nat. size.

The caterpillar of some of the swallow-tails always rests upon the middle of the upper surface of a leaf, upon the floor of which it has stretched a silken carpet, so as to make the edges curl toward each other, and thus form an open nest. On one rainy day, Mr. L. Trouvelot, of Cambridge, noticed a caterpillar of the Tiger Swallow-tail on a bush in his garden. "I certainly thought," he says,* "that the invention of resting in the hollow of a curved leaf on a rainy day was a very poor one; for since the bent leaf performed the office of a gutter, the water must flow

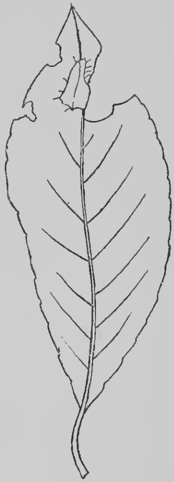


Fig. 94.—Nest of caterpillar of Thanaos Persius, nat. size.

* Proc. Bost. Soc. Nat. Hist., xii., 92 (1869).

through this channel, the larva be inundated and inevitably drowned, if the rain lasted but a few hours. I soon found that there were more brains in the small head than I had supposed. The larva began to move ; it spun some silk from one

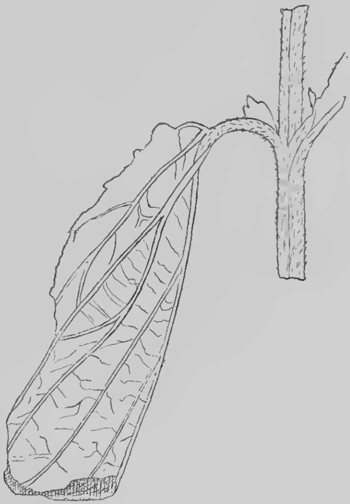


Fig. 95.—Nest of caterpillar of Vanessa Atalanta, formed of a nettle-leaf ; nat. size.

edge of the leaf to the other, and by adding many fibres to make it strong, each new fibre shorter than the preceding, the leaf was soon made to curve more and more. I then began to understand what this laborious work was for, and I thought that sometimes small people might give lessons to larger ones. After about an hour, the larva ceased to work, a real bridge was built over the torrent, and upon it lay motionless and out of danger the little larva. Would you call such an act instinct," he adds, "or would you call it reason? If you call it instinct, I would say that this instinct is very reasonable."

The caterpillar of the Red Admiral (Vanessa Atalanta) constructs a somewhat similar [Fig. 95] though more perfect nest by fastening together

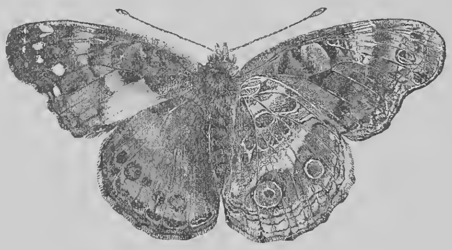


Fig. 96.—Vanessa Huntera, nat. size ; under surface on right (Harris).

the opposite edges of a nettle-leaf, the tip of which it eats when too lazy to go away from home, until there is barely enough left for shelter ; its weight causes the leaf to droop, so that the nest is easily discovered. Its next allies, the cosmopolitan Painted Lady (Vanessa cardui) and the American Painted Beauty (Vanessa Huntera), [Fig. 96], construct a different sort of nest, draw-ing together, by means of an irregular web, leaves, buds, and bitten fragments of the plant on which they feed, so as to form within a rounded cavity, with an opening just large enough to enter.

The Goatweed butterfly of the west (Anaea

FIG. 97.—Anaea Andria; *a*, caterpillar; *b*, chrysalis; *c*, leaf of goat-weed sewed at the edges to form nest of caterpillar; nat. size (Riley).

Andria) makes a nest [Fig. 97] very similar to that of the Red Admiral, but devours its upper instead of its lower part, until, having eaten itself out of house and home, it is forced to construct a new habitation.

But perhaps the most interesting nest of all is that made by the caterpillar of the Viceroy [Fig. 98]. This caterpillar hibernates when partly grown, and provides for the occasion a winter residence, which is occupied only during the cold season. For this purpose it eats the sides of a willow-leaf nearly to the midrib, for about one third the distance from the tip, ordinarily selecting for the purpose a leaf near the end of a twig; the opposite edges of the rest of this leaf it brings together, and not only fastens them firmly with

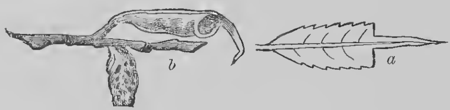


FIG. 98.—*a*, leaf of willow as cut by the caterpillar of Basilarchia Archippus for its hibernaculum; *b*, the hibernaculum formed; nat. size (Riley).

silk, but covers this nest outside and inside with a carpet of light-brown glossy silk, so that the leaf is nearly hidden; nor is this all; it travels back and forth on the leaf-stalk and around the twig, spinning its silk as it goes, until the leaf is firmly attached to the stalk, and in spite of frost and wind will easily hang until spring. Following the projecting midrib, the caterpillar creeps into this dark cell head foremost and closes the opening with its hinder segments, all abristle with spines and warts. The other species of the same genus, the Red-spotted and the Banded Purple, have the same habits ; the latter feeds on birches ; and if we examine these trees in early spring, when all sorts of ichneumon flies are just beginning to wander about in search of prey, we can hardly fail to be struck by the deceptive resemblance these hibernacula of the Banded Purple bear to the opening buds and curving terminal shoots of the very twig on which they occur [Fig. 99] ; the color of the soft down of the buds and the enveloping silk of the hibernacula is as similar as are their forms ; and this mimetic resemblance is doubtless as effective as it is interesting.

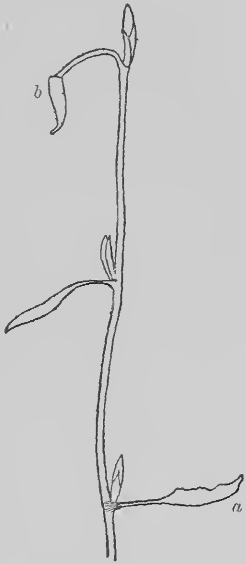


Fig. 99.—Hibernaculum (*a*) of Basilarchia Arthemis on a shoot of budding birch as it appears in June in the White Mountains, N. H., to show its resemblance to the buds (*b*) ; nat. size.

A large number of caterpillars attain their full growth and change to chrysalis before winter, passing the cold months in torpid sleep ; but besides the caterpillars of the purples, which hibernate when half grown, there are many others which hibernate at different times of caterpillar life. Most of the meadow browns or satyrs hatch from the egg late in the season, and hibernate before feeding upon anything more than their own egg-shells; one of them, however, the White Mountain butterfly, probably hibernates full grown, crawling for that purpose into crevices between the stones and rigid moss of the alpine heights where it lives. So, too, the caterpillars of our dusky wings, Thanaos [Figs. 100, 101] hibernate full fed, and only change to chrysalis as winter's icy bonds begin to break; but the winter histories of too many even of our commoner butterflies are unknown; though probably the larger number of hibernating caterpillars pass the winter in a half-grown condition.

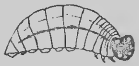


FIG. 100.—Caterpillar of Thanaos Ennius, nat. size.

FIG. 101.—Chrysalis of Thanaos Ennius, nat. size.

The only point of interest in the lives of chrysalids is their different mode of suspension; but as this will need to be fully mentioned in discussing the classification of butterflies, we will pass it by for the present, and consider the full-fledged butterfly.

Awaking from its long sleep, the creature finds itself arrayed in new beauty; ordinarily it has escaped from its prison-walls soon after sunrise, and for an hour or two it rests quietly until its moist wings are fully dried and expanded. Our new friend is a daughter of high noon. There are few butterflies abroad in New England before eight or nine o'clock of a summer's day, and long before nightfall, with closed wings, and antennae snugly packed between, they are quietly resting beneath some leaf or clinging to some grass-blade. Each species has its own peculiar haunts from which it may be easily stirred. Driving one morning within an hour after sunrise across the sandy plains of Nantucket, along a road fringed with a row of stunted pines some fifty feet from the track, a continuous stream of Blue-eyed Graylings (Cercyonis Alope) [see Figs. 143, 144] arose, stirred from the low tops of the bordering pines by the rumble of our wagon-wheels; none were to be seen either before or behind us, but on either side they constantly arose as we reached them, and, wafted by the wind, sank drowsily to the earth. Just before nightfall, at the proper season, one may readily discover the American Copper (Heodes Hypophlaeas) or the Clouded Sulphur (Eurymus Philodice) [Figs. 102–104], clinging head upward and with drooping wings to any common herbage.

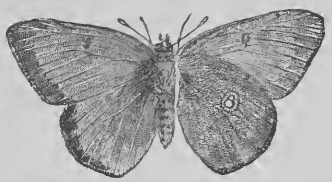


FIG. 102.—Eurymus Philodice, male, nat. size; under surface on right (Harris).

But we are sending our friend to bed before ever he has busied himself with the day! His

Fig. 103.—Eurymus Philodice, female, nat. size; under surface on right (Harris).

first thought appears to be of honey, and off he goes, probing every flower he meets, and spending the greater part of the time in this employment. Some butterflies are less greedy than others, and spend long hours in sunning themselves, resting upon the leaves of herbs or trees or perhaps upon the ground, gently half opening and shutting their wings; many kinds are of a lively and even pugnacious disposition, and perch themselves upon the tip of a twig or on a stone or some such outlook, and dash at the first butterfly that passes, especially if it be one of their own species; then the two advance and retreat, forward and backward, time

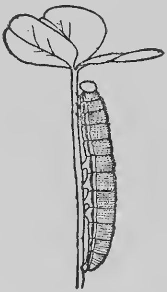


Fig. 104.—Caterpillar of Eurymus Philodice, nat. size.

and again, circle around each other with amazing celerity, all the while perchance mounting skyward, until suddenly they part, dash to the ground, and the now quiet pursuer again stations himself on the very spot he quitted for the fray. But they are not always particular to choose one of their own kind for this combat. Toss your hat in the air, and almost any of our Angle-Wings will dash at it and circle around it as it rises and falls ; and the little American Copper [Fig. 105], one of our smallest butterflies, will dart at every bulky grasshopper or locust that shoots across its field of vision.

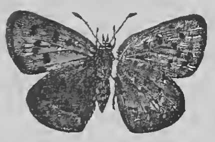


FIG. 105.—Heodes Hypophlaeas, nat. size ; under surface on right (Harris).

Some butterflies are as fond of water, or even of ordure, as they are of the sugared sweets of flowers. Every one must have noticed at the brink of roadside pools left by a recent rain, how the yellow butterflies will start up at one's approach, flutter about a few moments, and then settle down again to their repast. On favorable occasions, you may find them ranged by hundreds along the edge of a puddle, with wings erect, crowded as closely as they can be packed. The little azure butterflies congregate in the same way about moist spots in the roads through woods ; but as they choose less frequented places, this is not so common a sight. Our Tiger Swallow-tails throng about lilac-blossoms, and become so intoxicated that on one occasion a friend of mine caught sixty of them at once between his two hands.

The butterflies I have mentioned show an apparent fondness for each other's company, apart from the attractions of the flowers or the muddy road ; indeed, there are very few butterflies which, at the time of their greatest abundance, do not show a tendency to congregate. The Monarch, or Milk-weed Butterfly (Danais Plexippus) [Fig. 106], for example, may be seen quite by himself, sailing majestically over the fields, until late in the season, when, having multiplied to excess, vast swarms are found together ; together they mount in the air to lofty heights, as no other butterfly appears to do, and play about in ceaseless gyrations ; and sometimes they crowd so thickly upon a tree or bush, as by their color to change its whole appearance [Fig. 107] ; occasionally we hear of the migrations of butterflies in swarms, but they are of rare occurrence, and have mostly been observed in the tropics. Mr. W. Edwards, however, relates* how, from the top of Pegan Hill, in Natick, Massachusetts, he saw such a moving swarm flying steadily for hours in a single direc-

* American Naturalist, xi., 244.

FIG. 106.—Danais Plexippus, nat. size (Riley).

tion. They passed too high for recognition, although, by his description of their size and their mode of flight, it was probably the same butterfly which we have just mentioned.

The movements of butterflies on the wing are as different as the flights of birds, and just as an ornithologist may distinguish many birds by their

FIG. 107.—Cluster of Danais Plexippus, alighted on a bush; reduced. (After Thaxter.)

mode of flight when their form and colors are indistinguishable, so the observant entomologist may often determine a butterfly from a considerable distance. In the case of the entomologist, however, the decision is more difficult, since there are such rapid replacements of one species by another throughout the summer that direct comparison of the flight of similar species is often impossible.

This supplanting of one species by another, it may be added, is in wonderful adaptation to the parallel changes going on in the vegetable world, especially among the flowers. I do not know that any of our naturalists or artists have written of the harmony between the prevailing tints of a New England landscape at different times of the year, and of the insect world at the same seasons. Our common butterflies, which nature has been at such pains to adorn, show a shifting panorama of form and color from early spring to the time of frost. First, in the sombre leafless woods come the various dusky wings [Fig. 108], brown and black, skipping softly in and out among the gray rocks and over the dry leaves and dark pools of melting snow. Hard upon these, in the time of early violets, and frequenting the spots most loved by them, follow the little blue butterflies. Then, as spring fairly bursts upon us with its fresh and varied hues, come crowds of queenly swallow-tails, lustrous with metallic gleam [Fig. 109], or striped and belted with gay colors; and the banded and spotted purples that court the quiet

FIG. 108.—Thanaos Brizo, nat. size; under surface on right (Harris).

Fig. 109.—Laertias Philenor, nat. size (Riley.)

forest road and the brink of the mountain brook; the soft white butterflies [Figs. 110-112], that look too pure for earth, less retiring than the last,

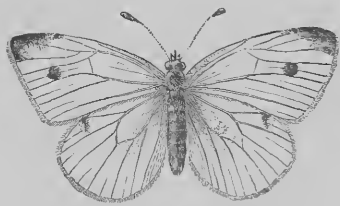


FIG. 110.—Pieris rapae, male, nat. size (Riley).

float about our gardens, alas! on sad intent; while the brisk little tawny and black skippers [Figs. 113-116] everywhere bustle and whisk about. Summer, with its blazing sun and diversified blossoms, brings us the hot-looking coppers [Fig. 117], and all that dappled band of fritilla-

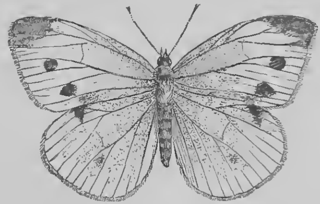


FIG. 111.—Pieris rapae, female, nat. size (Riley).

ries (Dryades) [Fig. 118] and angle-wings [Fig. 119], blocked in red and black above, and often variegated by odd dashes and spots of burnished

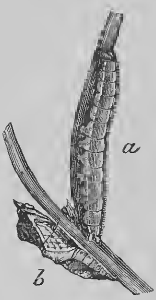


Fig. 112. —Caterpillar (*a*) and chrysalis (*b*) of Pieris rapae, nat. size (Riley).

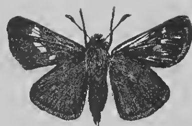


Fig. 113.—Limochores Taumas. female, nat. size ; under surface on right (Harris).

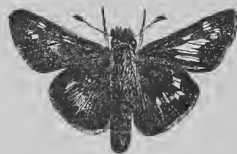


Fig. 114.—Anthomaster Leonardus, male, nat. size ; under surface on right (Harris).

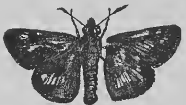


Fig. 115.—Polites Peckius, male, nat. size ; under surface on right (Harris).

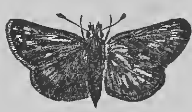


Fig. 116.—Polites Peckius, female, nat. size ; under surface on right (Harris).

Fig. 117.—Chrysophanus Thoe, nat. size ; under surface on right (Packard).

silver, or by peacock eyes beneath. How they crowd about the spreading thistle-blossoms, or on

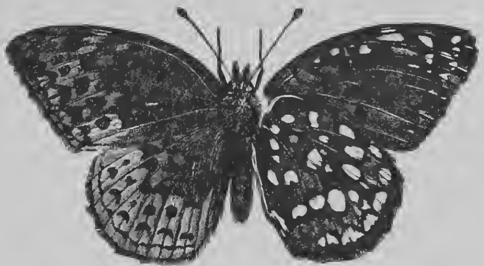


FIG. 118.—Argynnis Aphrodite, nat. size; under surface on right (Harris).

the many-flowered umbels of the milk-weed, and fan themselves with content at their sweet lot! As autumn approaches and the leaves grow dull,

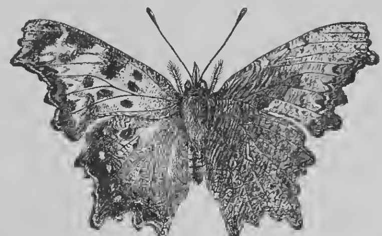


FIG. 119.—Polygonia Progne, nat. size ; under surface on right (Packard).

the grain ripens in the meadow and the pastures parch with drought, then come the satyrs or meadow-browns [Figs. 120, 121 ; see also Figs.

143, 144], lazily dancing by the roadside and over the thickets which skirt the fields; in the time of golden rods and yellow and blue asters the great

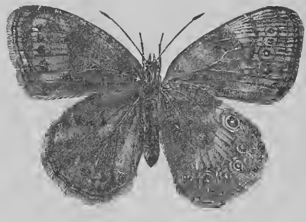


Fig. 120.—Satyrodes Eurydice, nat. size; under surface on right (Harris).

throng of yellow [see Figs. 102, 103] and orange butterflies appear; some of them are with us throughout the season, companions of the buttercup, the dandelion, and the rudbeckia; but now

Fig. 121.—Cissia Eurytus, nat. size; under surface on right (Harris).

they swarm, flitting busily in zigzag courses over upland pasture and lowland meadow, by marsh and brook, in field and fen, crowding around the open flowers, or dancing in pairs in mid-air.

CHAPTER VIII.

SEASONAL CHANGES AND HISTORIES.

The various aspect of the butterfly world at different seasons, to which allusion has just been made, is not so conspicuous as it would be did each species pass through its cycle of changes and transformations only once a year. This is the case, however, with the smaller portion of our butterflies. Most of them have two, and not a few three, broods each year, so that the same butterflies appear again and again throughout the season, or in some longer-lived species may be found in the butterfly state all the year round, one brood continuing upon the wing until the next is born. But as one season of the year differs from another in character, so is one brood of butterflies often subject to influences which the next avoids; this often provokes a diverse habit in different broods of the same insect. Some species, moreover, hibernate as butterflies; others as chrysalids; others, as we have seen already, as caterpillars; and a considerable number are dependent for the continuation of the species upon the power possessed by the egg to brave the winter's cold. It may then be easily imagined what complications of habits and histories are possible in the butterfly world, when the winter may be passed at any (though generally at a fixed) period of life, and when a species may be single-brooded, or may twice or thrice run the circle of its transformations within a single year. When, moreover, we recognize that these frequent repetitions of the cycle are largely due to temperature, and therefore vary to a certain extent with the latitude and even with the season, we can understand how nearly every variation we can conjecture finds its counterpart in the actual histories of our own butterflies. We will recite a few cases, each illustrating some peculiarity.

FIG. 122.—Thecla Calanus, nat. size ; under surface on left.

The Banded Hair-streak (Thecla Calanus) [Fig. 122] appears on the wing during July and lays its eggs toward the end of that month and early in August ; these eggs remain unhatched until the following spring, when the caterpillar emerges, feeds on oak-leaves, changes to chrysalis in June and July, and after a fortnight the butterflies of the new year appear.

The Bronze Copper (Chrysophanus Thoe) [see Fig. 117] also hibernates in the egg state, and although the butterflies produced from these eggs do not appear until the latter part of June, or only a little earlier than the Banded Hair-streak, and lay their eggs in July, these eggs hatch at once, and the caterpillars mature so rapidly that a new brood of butterflies appears by the middle or end of August, and lays its eggs during September ; and it is this second brood of eggs which passes over the winter.

The Brown Elfin (Incisalia Augustus) [Fig. 123] hibernates in the chrysalis state and, as might be expected, the butterflies appear early in spring ; indeed this species is one of our earliest, flying toward the end of April or very early in May ; by the end of May the butterflies, with rare exceptions, have disappeared ; the eggs hatch at once, and the caterpillars probably attain maturity in the latter part of June, change to chrysalis and remain in this condition throughout the hot season and until the following spring. Like the Banded Hair-streak, this insect is single-brooded, but it hibernates as a chrysalis instead of as an egg, and passes the hot season as a chrysalis instead of being then at the height of its metamorphoses ; the case, which is not an isolated one, is the more strange since warm weather ap-

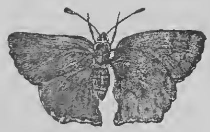


FIG. 123.—Incisalia Augustus, nat. size ; under surface on right (Harris).

pears in general to be the prime agent in the change from chrysalis to imago, and the period from June to September, when this butterfly is dormant in the chrysalis, is the very one when most butterflies are undergoing the greatest amount of change.

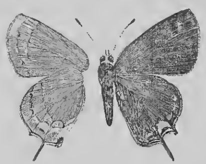


Fig. 124.—Uranotes Melinus, nat. size; under surface on left.

The Gray Hair-streak, or Hop-vine Thecla, as Harris calls it (Uranotes Melinus) [Fig. 124], flies from May to September, being long-lived in the imago state; it winters as a chrysalis, like the preceding, but it does not appear so early as that species, being seldom seen before the tenth of May; a second brood, sprung from the eggs laid by the May butterflies, makes its advent early in July, or occasionally late in June; fresh accessions to its numbers from belated chrysalids are made throughout July, and these later ones may be found, with faded beauty, even until the middle of September; from eggs laid by this second brood of butterflies spring the chrysalids which survive the winter.

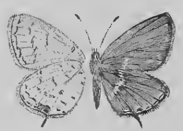


Fig. 125.—Everes Comyntas, nat. size; under surface on left.

The Tailed Blue (Everes Comyntas) [Fig. 125] is also supposed to winter in the chrysalis. It is triple-brooded, yet it appears no earlier than the preceding double-brooded butterfly, namely, between the sixth and tenth of May ; by the middle of June, sometimes by the end of the first week, it has disappeared, and within two months of its first appearance is once more upon the wing ; by the end of July it has again become scarce, though occasional specimens persist until the third generation has made its appearance, about six weeks after the appearance of the second, or about the twentieth of August. Butterflies of this third brood may be found nearly throughout September, and doubtless lay their eggs early in September, giving the caterpillar time to attain its full growth and change to chrysalis before winter.

All these examples have been taken from a single family of butterflies, comprising the hairstreaks, blues, and coppers, to show how different the histories of allied insects may be. Yet it rarely happens in this family that winter is passed either in the larva or imago state, and we therefore hardly expect to find the complication we may look for elsewhere. Choosing our examples then from all the families of butterflies, we will continue our histories with an eye to further differences.

Commencing with those which winter as caterpillars, we may instance the Blue-eyed Grayling [see Figs. 143, 144], which is single-brooded and first appears on the wing in the early half of July. As usual among butterflies, the males are seen about a week before the females, but even taking this into account the females live a long while before depositing a single egg; the earliest record I have of this event is the twenty-second of August, or from five to six weeks after the first appearance of females; they continue to lay eggs until the end of the first week in September; and in keeping with this indolence of the females is the duration of the egg-state—from three to four weeks, a period longer than in any butterfly known to me where the eggs hatch at all the same season. The earliest caterpillars therefore appear by the middle of September, at which time their food-plant, grass, is still abundant, and plenty of it green and succulent; yet the habit of the species is fixed, and the larva will exhibit no haste; it will devour its egg-shell quite as a matter of course, but that digested, it crawls into some corner of a dead stick or a dry leaf and starves till spring-time. Remove it to a warm room and place it among new springing grass; the result is the same, at least for a time; I have not tried it very long; it cannot be cajoled into eating. The further exact history of this insect in New England is unknown, but in West Virginia the chrysalis state continues for a fortnight. In New England the perfect insect appears later in the season than almost any other single-brooded butterfly; the conditions, however, under which it passes the winter are common to many of our butterflies.

We have already stated that the Viceroy [see Fig. 84] hibernated as a caterpillar; but there are some interesting features in its history which may now be related. Quite as soon as there is a morsel of food to eat on the twig which has been its winter home, it forsakes its retreat in the curled leaf, and breaks its long fast. The butterflies developed from the wintering caterpillars appear early in June, become abundant by the middle of the month, and continue for another fortnight to emerge from the chrysalis; about a month after the first appearance of the males the females begin to lay eggs; the caterpillars soon hatch and grow rapidly, and late in July change to chrysalis; in this state they continue about eight days, and before the middle of August a new brood of butterflies is abroad. The caterpillars from eggs laid by this brood are those which construct the little hibernacula wherein they find protection from the wintry cold; no trace of any tendency to construct such habitations appears in the caterpillars of the first brood; here we have an instinct inherited by alternate generations; or only when the nightly chills or the desiccating food indicates the coming of an unfriendly season.

Take next our commonest yellow butterfly, the Clouded Sulphur, familiar to every one [see Figs. 102, 103]. The first brood of butterflies, which is also the least numerous, appears about Boston, on warm sunny hillsides, sometimes as early as the twenty-fourth of April, sometimes not until toward the middle of May, the advent of this insect being more than usually affected by the season. Toward the end of May it becomes very abundant, then begins to diminish in numbers, until only a few rubbed females remain when the next brood appears; the females begin to lay eggs very soon after birth, the eggs hatch in five days, and the caterpillars often attain their full growth in three weeks, while the chrysalis state lasts from nine to eleven days. The appearance of the second brood is varied, like the first, according to the latitude; in the vicinity of Boston it usually appears during the first week in July; the caterpillars of this brood mature quite as rapidly as those of the previous, and numbers of the butterflies are sure to be on the wing at the advent of the third brood, which is occasionally as early as mid-August, but often is delayed until September; the butterflies of this last brood are still numerous in the middle of October, and continue flying until after the first severe frost; some have even been seen in the neighborhood of Boston as late as the middle of November. As the eggs of this brood are laid throughout September and even later, and at this season the caterpillars do not mature so rapidly, winter overtakes at once caterpillars of various ages, chrysalids, and butterflies, and probably also eggs. The experience of breeders, and the diversity in the time of appearance of the butterflies in the spring, render it probable that the cold season kills not only the butterflies and eggs, but perhaps the chrysalids as well, leaving the caterpillars to renew the life of the species in the spring. Indeed it is a common thing in plural-brooded butterflies to find every possible stage on the ground as winter comes on ; for the more the number of broods is multiplied, the more confused do the distinctions between them become ; and in many cases, were the season longer, no doubt it would become quite impossible to trace them. The butterflies go on sucking honey and laying eggs, the eggs hatching, the caterpillars eating, until a heavy frost kills off all the unprepared and terminates the history of the species for the season ; those of one stage survive the shock, the others die ; this is the case with several of our swallow-tails and yellow butterflies and with not a few others ; sometimes it is the caterpillar, sometimes the chrysalis, at others the butterfly which survives ; the egg, in such cases, never.

Now let us turn, finally, to those which winter as butterflies, and consider, first, the Milk-weed butterfly, or Monarch [see Fig. 106]. It is the longest-lived of our butterflies. It leaves its winter-quarters later in the season than other hibernating butterflies, and continues upon the wing until July and August, laying eggs all the time, so that the insect may be found in all its earlier stages throughout most of the summer ; the eggs hatch in four or five days ; the caterpillar attains its full growth in two or three weeks, and the chrysalis hangs from nine to fifteen days. Whether or not there is a second brood in New England is doubtful ; but the earliest butterflies which have not hibernated may be found in July, so that while the earlier stages are passed rapidly, the perfect insect often lives a full year, mingling on the wing with its own progeny and witnessing the decay and renewed growth of the plant which nourished it ; for the milk-weed dies early, and is not sufficiently grown to support the caterpillars when the first butterflies appear in the spring.

The Green Comma (Polygonia Faunus) [Fig. 126], of the hill-country of New England, has a history which may serve as an example of most of our angle-winged butterflies. The first warm days of spring lure it from its winter hiding-places, but it is not until the end of May that it begins to lay eggs ; these soon hatch, the caterpillars reach maturity by the end of June or later, the chrysalis hangs about twelve days, and by the middle of July a new brood is on the wing, mingling with a few surviving parents. By mid-August it is found in the greatest profusion, and continues on the wing, in numbers constantly reduced by death, until October, when the survivors go into winter quarters, and before the end of the month the last have disappeared. None of

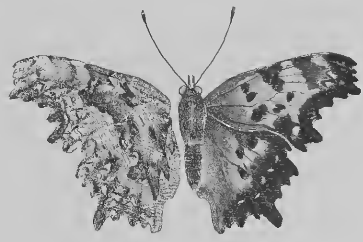


FIG. 126.—Polygonia Faunus, nat. size; under surface on left.

these butterflies lay eggs until the following spring.

Another of the angle-wings, the Nettle Tortoise-shell [Fig. 127], has a slightly different history, flying, as it does, at three different times. The hibernating butterflies appear by the middle of March, in scanty numbers at first, more numerously afterward, and continue on the wing until nearly the end of May. They lay their eggs on the young nettle plants late in April and early in

May, and the caterpillars begin to change to chrysalids in the first half of June ; after passing from ten to twelve days in this state, or about the middle of June, the first brood of butterflies from caterpillars of the same year makes its appearance ; this brood continues on the wing until after the middle of July, the eggs are apparently laid

FIG. 127.—Aglais Milberti, nat. size (Harris).

very soon after the eclosion of the butterfly, and the second brood appears at the very end of this month, or early in August ; these must lay their eggs at once, for the caterpillars are full grown by the end of August, and appear as butterflies early in September, before those of the previous brood have disappeared ; these September butterflies soon hibernate, and early in the following spring deposit eggs, which, unlike their sisters of the previous broods, they must carry unlaid for many months. We have again in this insect an illustration of the prodigality of nature, to which reference has been made ; for winter overtakes it in every stage and kills off all that cannot withstand the cold, the butterfly and perhaps an occasional chrysalis alone surviving.

For, besides those which pass the winter in only one of the four stages of life, there are others, and perhaps the Tortoise-shell is one of them, which enjoy a great liberty in this respect ; but

Fig. 128.—Vanessa Atalanta, nat. size ; under surface on right (Harris).

the Red Admiral [Fig. 128] is a better example. This butterfly, common to Europe and America, hibernates in both countries alike in the chrysalis and imago state. In the spring, hibernating butterflies and those hatched from wintering pupae mingle on the wing and deposit their eggs simultaneously. The wintering imago awakes late from its long sleep, being seldom seen before the beginning of the second week in May ; and since individuals emerging from wintering chrysalids often appear by the last week in the same month and continue to emerge until the middle of June, battered and brilliant specimens from the same original stock may be seen flying in company. Caterpillars of various ages from eggs laid by these butterflies may be found through nearly the whole of June and the first half of July; the chrysalids hang for about ten days and the butterflies appear in the first days of July and continue to emerge from the chrysalis throughout the month; the eggs are soon laid again, and another brood of caterpillars may be found in August; butterflies from these appear late in August and early in September, and continue a long while upon the wing, as they are among the last of our hibernating butterflies to seek their winter quarters; not all the chrysalids, however, disclose the butterfly, but some of these also hibernate. We have, therefore, a double-brooded butterfly of which specimens fresh from the chrysalis may be found upon the wing three times a year, winter approaching in the midst of the season of pupation, and arresting the development of a portion of the brood.

Mixed modes of hibernation may also be found in other butterflies; some, like our common American Copper [see Fig. 105], pass the winter both as a caterpillar and a chrysalis; and others, like the Cloudless Sulphur (Catopsilia Eubule) of the Middle States, as a caterpillar and a butterfly; this last instance is the more striking since the insect appears to be unable to survive the winter in the intermediate chrysalis stage.

It is not always the cold of winter, however, which causes an arrest of development; for there is a most extraordinary phenomenon in the life history of some butterflies, which arises in midsummer; viz., a period of lethargy or premature hibernation. It may occur in the eggs, as in the case we cited of some of the hair-streaks, where these remain unhatched from July or August until the next spring. It may also be found in some chrysalids, where, as in the eggs, it is merely early hibernation. But there are others, and doubtless more than we know, where it assumes peculiar characteristics. Notice, for example, the Zebra Swallow-tail (Iphiclides Ajax) of the south. This butterfly passes through the excessive number of four or five broods each season; but only a portion of the chrysalids of each brood disclose the butterfly the same season; the remainder, in numbers constantly increasing with each successive brood, go into premature hibernation, some even as early as June, and do not disclose the butterfly until the following spring; so that the spring brood of each year is made up of fragments of all the last year's broods. One may easily divine what complication might ensue through some modification of such a phenomenon.

But this feature is most curious when it affects the active stages of an insect's life. Beyond the torpidity of winter, we do not know that such a phenomenon occurs in the perfect stage; but it is by no means an uncommon occurrence among caterpillars, although, so far as we know, it does not happen outside of certain limited groups. In some cases it is simply premature hibernation; in others it is pure lethargy, the caterpillar affected by it awaking from its torpidity during the same season and resuming its active gluttonous life, as if nothing had happened.

One of the most extraordinary cases occurs among the fritillaries, and was first observed by a French naturalist, Vaudouer; according to this observer, one of the European fritillaries upon which he experimented flies in May and again in July and August; the caterpillars from the second summer brood are half grown when winter comes, hibernate in this stage, and in time produce the spring brood; the caterpillars of the spring brood, when they have reached the hibernating age, late in June, act in a precisely similar manner, and some of them do not arouse until the succeeding spring, when, with the caterpillars of the summer brood, they produce a new spring brood; but other caterpillars of the spring brood, which became lethargic, awaken from their torpidity after a time, resume eating, undergo their transformations, and emerge as butterflies in July and August; the spring brood is therefore made up from both broods of the previous year, or, in other words, uncles and nephews, aunts and nieces, have virtually become brothers and sisters, and the butterfly is *at the same time* single and double brooded.

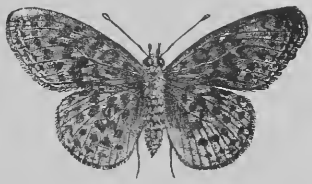


FIG. 129.—Brenthis Bellona, nat. size; upper surface (Harris).

We have, however, in this country a still more remarkable case in a near relative of the butterfly just discussed, the Meadow Fritillary (Brenthis Bellona) [Figs. 129–132]. This butterfly appears on the wing in May, July, and September, and yet it is only single-brooded, at least if we have correctly interpreted all the facts. In this species there seem to be two sets of individuals, each following its own cycle of changes, apparently with almost as little to do with the other set as if it were a distinct species; each set has its own distinct seasons, and this gives rise to the apparition of

FIG. 130—Brenthis Bellona, nat. size; under surface (Harris).

two or three successive broods in the course of the year.

At the very end of the season this butterfly will be found laying eggs, which hatch in a few days; the little caterpillars, after devouring their egg-shells, refuse further food and hibernate; these hibernating juvenile larvae belong to one of the two sets of individuals mentioned; this we will term the aestival or summer series; for by the end of the following June the caterpillars have attained their growth, and passing through the chrysalis state, emerge as butterflies about the middle of July; these are the butterflies of midsummer, continuing upon the wing until the end of September, in which month they deposit their eggs; these eggs hatch in about a week, and the little caterpillars hibernate as before. The history of this aestival series is quite similar to that of the larger fritillaries, all of which are single-brooded, appear in early summer, lay their eggs early in the autumn, and hibernate as juvenile larvae.

FIG. 131.—Brenthis Myrina, nat. size; under surface on right (Harris). Placed here for comparison with B. Bellona.

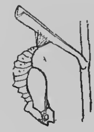


FIG. 132.—Chrysalis of Brenthis Myrina, nat. size.

The second set of individuals, which we will term the vernal, in contrast to the aestival series, hibernate as half-grown caterpillars and produce the earliest brood of butterflies ; these make their appearance about the middle of May, although they are occasionally seen earlier ; they are hardly common before the end of the month, and are as long-lived as their companions of the aestival series ; they do not lay their eggs before July or the end of June—that is, about the time when the butterflies of the aestival series appear ; the eggs hatch speedily and the caterpillars grow as usual, moulting twice ; beyond this point all the caterpillars do not develop alike ; some continue in what would appear the most natural way ; as caterpillars they eat, as chrysalids they sleep, and then appear in September, gay and frolicsome butterflies—but doomed, I believe, to an untimely end ; for the cold autumnal blasts sweep them away before the eggs are fully developed in their ovaries. It is, however, possible that some of them may lay eggs which, hatching, produce larvae which at once hibernate and the following year become members of the aestival series.* It appears more probable,

* Since this was written, some facts have come under my own and others' observation, leading to the belief, as suggested in the text as possible, that the butterflies of this brood lay eggs at once, and that the caterpillars from them hibernate in their earliest stage, thus transferring their allegiance the following

however, that it is a vain effort of nature to develop a second brood, which in a more southern climate, with a longer season, would prove successful.

But this we have said was the history of a part only and probably of the smaller part ; the other portion of the August caterpillars do not awake from their lethargy at all until another season, wintering as half-grown larvae, and finally reappearing as butterflies the following June.

Thus we have two series of individuals in the same species, each single-brooded, or one making an effort toward a second generation, which probably ends in disaster, or at most eventually feeds the other series.

In all plural-brooded butterflies with an extensive distribution in latitude, the number of generations varies with the length of the season, and this will account for the apparent waste we often see as winter approaches, for such changes must be gradual, and in intermediate districts irregular, dependent upon the season. Where such a phenomenon occurs as that we noticed in the Zebra Swallow tail [see Figs. 145–147], in which some chrysalids of each brood live until the following spring, it manifestly makes little difference how short the season may be, or how sud-

spring to the aestival series ; in which case the butterfly is generally single, occasionally double brooded.

denly and effectually any brood may be cut off; these chrysalids, and so the species, will survive. That this phenomenon is more common than is generally supposed is shown by the increasing number of proofs brought forward of lethargic tendencies in caterpillars and of persistent torpor in many midsummer chrysalids. It is also indicated by the variation in the numerical proportions of different broods; the winter is the severest season, and consequently the spring broods are ordinarily, and under simple conditions would always be, less numerous than the summer or autumn broods; generally the broods go on increasing in individuals as the season advances; but in the Meadow Fritillary it is not so, and we have seen the reason why; for it is made up of only a part of the previous brood. We see similar phenomena in other butterflies without knowing the cause, and it may be presumed that these are butterflies which have not long enjoyed the privilege of the later brood, or, in other words, in which a part of the chrysalids fail to persist until the following spring. In the case of our Tiger Swallow-tail, which is found from Alaska to Florida, we have a butterfly which is single-brooded in the north and double-brooded in New England; but the second brood is much less abundant than the first, and the change as we go north is probably effected by the lingering development of some caterpillars and the disposition of chrysalids to winter early. Wherever in a double-brooded butterfly the second brood is less abundant than the first, it is probable that the butterfly is partly single and partly double brooded—that is, that the early brood of a given year is made up of the direct descendants of each brood of the preceding year.

Occasionally, the difference in the number of broods affects the mode of hibernation. The Black Swallow-tail (Princeps Polyxenes), for instance, is triple-brooded in the south, and hibernates as a butterfly and perhaps also as a chrysalis ; in the north it is double-brooded, and hibernates only as a chrysalis.

To return again to our Meadow Fritillary with its curious history. Should the season be so long that the second brood of the vernal series could lay eggs, these eggs would at once hatch, for their normal period being often as short as five days, weather which could induce a butterfly to lay eggs would at once ripen the embryo ; the caterpillars would then be forced to hibernate in the same condition as those of the aestival series, and become members of that series the next year ; while the vernal series would be kept up by means of those caterpillars of its first brood which, in the previous year, had gone into premature hibernation. Thus the vernal series would continually feed the aestival ; yet it would suffer no greater loss than by the practical sterility of the September butterflies. Were the season still longer, the vernal series would become double-brooded, the caterpillars from the September butterflies having time to attain half their size before hibernation ; the aestival series, on the other hand, would probably by this time have assumed the position our vernal series occupied at the outset, and adopted and monopolized the lethargic propensities of the latter.

The preceding hypothesis was suggested several years since to explain the probable effect of climate on generation in butterflies ; it was not deemed capable of proof, inasmuch as the butterfly does not naturally live in a climate allowing of such changes. But it has received a remarkable confirmation in some forced experiments of Mr. Edwards of West Virginia, who has pointed out that caterpillars of this species carried from the north to West Virginia and raised in the south acted in precisely the way that had been suggested ;* they all went through their transforma-

* These observations of Mr. Edwards were published in the Canadian Entomologist (volume vii. p. 189 *seq.*; see also vol. viii. p. 161), and were not unreasonably supposed by him and others to be opposed to the account of the insect I had previously given. They may be so, but the author neglected to state that the caterpillars raised by him were reared in West Virginia south of the natural range of the insect (as in response to my

tions without lethargic retardation, and the butterflies which emerged in the autumn laid eggs; if eggs were laid, we may presume they hatched, and the young caterpillars hibernated.

If now we suppose a shorter season, such as actually exists in some parts of our country where this butterfly occurs, undoubtedly the first change would be the entire elimination of the September butterflies and the hibernation of all the vernal caterpillars when half grown; this is probably the actual state of things in parts of Canada; still farther north these caterpillars would probably by degrees hibernate when first born, and we should then be transported to the simple condition which prevails in the larger fritillaries [Fig. 133], and have only one flight of butterflies in the season.

Fig. 133.—Chrysalis of Argynnis Atlantis, nat. size.

What may be the exact climatic features which determine the number of generations of a butterfly has not yet been studied; but there are some curious difficulties in the way of understanding

special inquiries he afterward informed me), and this gives his account an entirely different appearance. It is to be regretted that this able and industrious observer has since then given the history of other butterflies without informing us whether they were reared in New York or West Virginia, in both of which regions, four degrees of latitude apart, he is accustomed to rear insects.

them. The cosmopolitan Painted Lady [Fig. 134], for instance, is double-brooded in New England, both in the districts where the contrasts of heat and cold, moisture and drought, are excessive—that is, where the climate has those peculiarities which are termed "continental;" and also on islands such as Nantucket in southern New England, where a much greater evenness prevails and the climate partakes of an "insular" character; yet in the valleys of Switzerland, where perhaps

FIG. 134.—Vanessa cardui, nat. size; under surface on right (Harris).

of all places in Europe the climate presents the greatest and most sudden inequalities, and therefore is most similar to that of New England, and certainly is more continental than that of Nantucket, this butterfly is single-brooded. We have exceedingly few identical butterflies in Europe and the United States, and this apparently is the only one of them that differs in its broods in the two countries; but there are several of our butterflies which are represented by very closely allied species in Europe, and in half a dozen or more of these we find quite similar disparities, all of which are in the same direction.

The European Tortoise-shell (Aglais urticae), for example, is generally double-brooded; occasionally a triple brood is mentioned; it is one of the commonest of European butterflies, and reaches from the North Cape to the Mediterranean; our congeneric species, the Nettle Tortoise-shell [see Fig. 127], is rarely found south of the northernmost parts of the United States, and yet it is triple-brooded in all parts of Canada. Everes Amyntas, again, occurs throughout Europe, with the exception of certain northern and northwestern portions, and is double-brooded; our Tailed Blue [see Fig. 125], named for the resemblance to its European congener, and by some careless authors considered identical with it, is also a wide-spread insect; but even in New England, which is toward the northern limit of its range, it is triple-brooded. The wide-spread European blues, Rusticus Argus and R. Aegon, the Silver-studded Blue, are usually placed among monogoneutic insects, and the latter certainly has only a single brood in England (where it is the only one of the two found); Meyer Dür is in fact almost the only author who claims these species as digoneutic; both of them occur in southern Europe; the American Pearl-studded Violet (Rusticus Scudderii), closely allied to these, and an insect hardly known south of the Canadian border, is double-brooded. Our Chequered White (Pontia Proto-

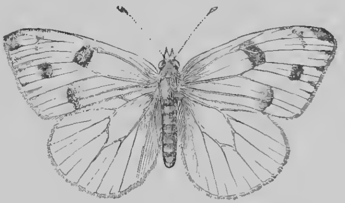


FIG. 135.—Pontia Protodice, male, nat. size (Riley).

dice) [Figs. 135, 136] is triple-brooded, and the European Bath White (P. Daplidice) only double-brooded, while our common Clouded and Orange Sulphurs (Eurymus Philodice and E. Eurytheme)

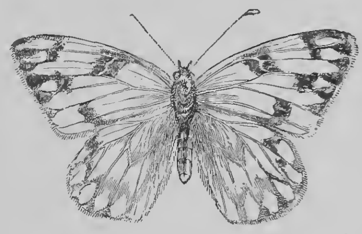


FIG. 136.—Pontia Protodice, female, nat. size (Riley).

[see Figs. 102, 103] are triple-brooded in the north, perhaps polygoneutic farther south, and the closely allied European species only single or double brooded.

But the most striking example of all will be found in the species of the genus Iphiclides. The European I. Podalirius is confined to the Mediterranean region, while our Zebra Swallow-tail belongs to the southern half of the United States; the regions are therefore fairly comparable; yet we find no mention of more than two broods of I. Podalirius, while Mr. Edwards has shown that, even as far north as the Appalachian valley of West Virginia, I. Ajax has four and sometimes five generations during the year.

These cases might perhaps be multiplied, but further positive evidence is not at hand; it should be remarked, however, that there is no reversal of the rule: among all the butterflies properly comparable on the two continents, *there is no single instance where the European butterfly has more broods than the American.*

This result of a comparison of the annual histories of similar European and American butterflies furnishes but another instance of that intensity which seems to characterize all life in America. The expenditure of nervous and vital energy, against which physicians vainly inveigh, which superannuates our merchants, lawyers, clergymen, and other professional men, is not induced by the simple passion for gain, place, power or knowledge, but by an uncontrollable restlessness, a constant dissatisfaction with present attainments which marks us as a hurrying, energetic, enterprising people. My own experience has been that studies of precisely the same nature and undertaken under similar external conditions are accompanied by a very different mental state on the two continents. In Europe we are content to plod industriously on, unconscious of the need of relaxation ; in America we bend with nervous intensity to our work, and carry the same excitement into the relaxation which such a life inevitably demands. After a long absence in Europe, a keen observer may even be directly conscious of this quickened life.

Now to what shall we ascribe such peculiarities in animal life ? Naturally we look to climatic influences, and our attention is first attracted by the well-known fact that if we compare two places in Europe and America having the same mean annual temperature, the extremes of variation will prove much greater on this side of the Atlantic. For example, while the mean annual temperature of New York is about the same as that of Frankfort, the summer temperature of the former is that of Rome and its winter that of St. Petersburg. Moreover, the changes from summer to winter and from winter to summer are more immediate in America ; or, in other words, the summers and winters are longer by about three weeks. Such long and hot summers are of course favorable to the multiplication of broods in butterflies whose history allows a repetition of the same cycle more than once a year ; the length of the winter is of slight consequence, as long as the insects can survive it ; and it can have no influence upon the number of broods, unless there be species (of which we know nothing) able to resist a cold winter only in certain stages of existence, and a multiplication of whose broods might require some pliability in this respect. Not only, too, are our summers longer and hotter, but they enjoy a marked preponderance of sunshine, as compared with European summers ; and this alone would almost seem capable of producing the variation we have noticed in the number of broods.

Differences will be found in all other climatic phenomena of the two continents. "From Europe as a standard," says Blodgett,* "the American climate is singularly extreme both in temperature, humidity, quantity of rain, wind, and cloudiness or sensible humidity. The oscillations of the conditions are greater, and they vibrate through long measures above and below the average. All the irregular as well as regular changes are of this sort, and the European observer defines the climate as directly antagonistic to

* Climatology of the United States, p. 221.

that he has left.'' These differences, however, as Humboldt and others long ago pointed out, have a broader bearing than the above statements would imply ; for they are characteristic of the eastern shores of both worlds as opposed to the western, the meteorological phenomena of the eastern United States being almost precisely paralleled by those of northern China, where great excesses of temperature occur, with wide variability, long summers and winters, and rapid transitions.

Perhaps on these grounds we can most simply account for the difference in the number of broods in certain butterflies on the two continents ; but, if so, then it follows that we ought to anticipate similar differences between the broods of some of the species found both in Europe and in eastern Asia ; a point of which we can assert absolutely nothing, for want of data. These grounds, however, will certainly be insufficient to account for the differences to which we have alluded in man ; for what contrast could well be greater than that existing between the national character of the Chinese and that of the Americans ! We are rather forced to believe that the causes of the distinction between the European and the American, if these are due to physical agencies, must chiefly be sought elsewhere.

I have thus attempted to show that the lives of butterflies possess no mean interest, and that we are probably still far from understanding all the complications which arise in the history of a single one of those which are double-brooded or have a wide geographical distribution. If any of my readers have been puzzled by their strangeness, and think that perhaps I have drawn the picture with too free a hand, let me assure them that, for simplicity's sake, I have been forced to keep quite out of view one element of discord by which the complexity is often vastly increased, and to which I shall next invite attention.

CHAPTER IX.

THE COLORING OF BUTTERFLIES, WITH FURTHER HISTORIES.

In discussing the subject of coloring in butterflies, I do not intend to present it from the poet's point of view, seductive as this might be, but to excite interest and quicken imagination in a more prosaic way; namely, by pointing out some of the laws which govern this coloring, and some of the lines by which the present tribes have attained their gorgeous hues and exquisite design; in short, to present, through the medium of observation and fact, some cause for this rich display and variety.

For myself, I confess that such a discussion possesses a greater charm than any poetic rhapsody, however exquisitely framed, which merely recounts the wondrous beauty of these delicate creatures. If, beneath this display, we can discover Almighty wisdom, ordaining and harmonizing color and design, and can appreciate in some measure the adaptation of this embellishment to the creature's environment, our time will not be misspent.

In butterflies, as in other animals, species of the widest distribution usually display the greatest variety in their characteristic peculiarities ; nowhere is this more true than in their coloring. Latitude, especially, has an influence in these alterations, and altitude produces almost precisely the same effects as latitude. Many species present so different an aspect at the northern and southern extremities of their range as to have been described as distinct species. So we may discover a difference of considerable importance in the coloring of butterflies as a whole, in passing from the tropics toward the poles, just as we observe a certain procession of color during the season, as one species is replaced by another. Every one is aware that the most brilliant tints among birds and butterflies are found in the tropics, while the sombre shades are more in sympathy with the gloomier subarctic regions. Prittwitz* and Meyer-Dür† have studied this question in the European Lepidoptera as a whole, and, with some exceptions, we may accept their generalizations as applicable to the butterflies of our own country.

The highest life of color in the wings of butterflies consists in sharply defined spots of red, blue, and yellow, and especially of red. These colors predominate in the tropical re-

* Stett. entom. Zeit., xvi., 175.

† Actes Soc. Helvét. Sc. Nat., Vers. xxxvii. 145–152.

gions, and are rare in alpine and subarctic districts. As we go north, the colors become less sharply defined, then gradually fade away or become blended with surrounding tints; the red first disappears, the blue follows, the yellow longest maintaining its hold, although Prittwitz considers the blue the most persistent. As soon as we leave the tropics these brighter colors are seldom seen in combination; and as we approach the higher temperate regions, we are constantly struck by the impurity of the tints. Take a single example from the common sulphur butterflies of the genus Eurymus [see Figs. 102, 103]; the more southern species have the under surface of the hind wings of a clear canary yellow, and what few spots they possess are clustered into sharply defined markings next the margin; these features predominate until we arrive at the Middle States, when a change begins; and on reaching Labrador we find the opposite extreme, a ground color of greenish yellow completely flecked with atoms of brown, giving the wing a grimy appearance; while the marginal markings are simply more densely clustered atoms, forming spots which gradually pass into the general dinginess of the wing.

This loss of purity and greater or less suffusion of markings is characteristic of northern and alpine forms, and is in perfect accord with another phenomenon, the appearance of those varieties or sports which are called examples of suffusion. Although they frequently seem very unlike the normal form, a little study always suffices to show to what species they belong. This disguise is produced by the blending of certain colors, especially of black, white, or silvery tints, which normally occur at distinct parts of the wing; there may be, for example, two parallel series of white spots normally crossing the wing in the middle and near the border; under this disguise of suffusion, the whole intervening area is covered or shot with this color, generally more or less sprinkled with atoms of the normal ground, producing an impure tint, characteristic of northern countries. Now these suffusions have been known almost exclusively from the temperate regions,* and to show that they are not excessively rare, I may add that I have seen nearly fifty specimens of our common American Copper, and we are acquainted with at least eighteen of the two hundred and seven butterflies of the eastern United States in which such suffusions occur. A large number have been recorded in Europe, where they are commonest in the alpine districts of Switzerland.

These general changes of prevailing tints among

* Mr. Edwards of West Virginia has artificially produced a number of instances by subjecting chrysalids to unusual cold.

butterflies from the tropics northward are perhaps less striking because so gradual, and seem fairly connected with physical conditions ; color is dependent upon light, and of course the greatest intensity and duration of light is in the tropics ; the two phenomena are completely parallel. It is, however, harder to understand a very curious

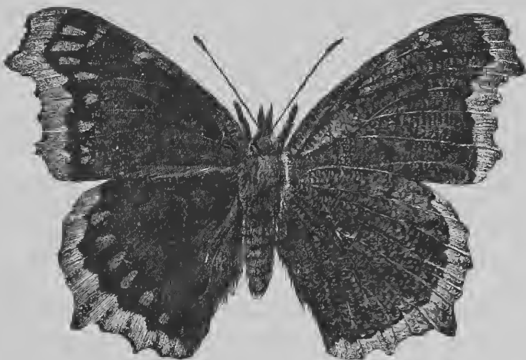


FIG. 137.—Papilio Antiopa, nat. size ; under surface on right (Harris).

sport in one of our butterflies, which is known to have originated within ten years. There are a very few butterflies common to this country and Europe ; three, the Painted Lady, the Red Admiral, and the Camberwell Beauty [Fig. 137], have long been known to inhabit both countries ; and not a few entomologists have attempted to find some difference between representatives from either continent, thus far without real success. Within a few years the cabbage butterfly [see Figs. 110, 111] was accidentally introduced from Europe, and has now spread widely; nor does any difference exist between European and ordinary American examples of this insect. But there has suddenly appeared in this country a variety unknown to Europe, or, if known, excessively rare, in which the normal chalky white, which forms almost the only color of the wings, is replaced by a pale sulphur tint; probably few of our entomologists have not seen this variety, although from its resemblance on the wing to our commonest of butterflies, the Clouded Sulphur, it would ordinarily escape observation.

At the close of the last chapter, I promised to discuss a new element of complexity which arises in considering the different broods of butterflies; this complexity, it would seem, is already sufficiently embarrassing, when we have lethargy of the caterpillar, or premature hibernation of the chrysalis, with the consequent commingling of broods; but in addition to this the successive broods of the same butterfly which appear in a single season almost always differ from each other; often so incredibly as to be mistaken for distinct species. This phenomenon is termed alternate, or, better, seasonal dimorphism—dimorphism signifying the existence of an animal under two distinct forms.

The imported Cabbage butterfly [see Figs. 110, 111] just mentioned is a case in point; the spring butterflies are smaller and of a duller white than the later broods, with broader black markings on the middle and tip of the wing, and the base sprinkled with black atoms, which are almost entirely wanting in the other broods; beneath, where the markings in this genus are most conspicuous and varied, there is a powdery streak of black scales along the middle of the hind wings, which, in the later broods, is much less conspicuous.

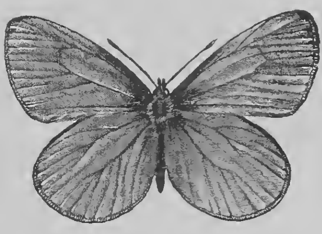


Fig. 138.—Pieris oleracea, nat. size (Harris).

A somewhat similar distinction occurs in its near ally, the Gray-veined White [Figs. 138, 139]. The summer brood of this species is almost pure white, while the spring brood, besides being smaller, has the under surface of the hind wings and of the tip of the fore wings heavily washed with yellow, and all the veins in the same area broadly sprinkled with dark scales. Moreover, in all the whites, the hind wings of the second generation are longer than those of the first.

Fig. 139.—Chrysalis of Pieris oleracea, nat. size (Riley).

In the American Copper [see Fig. 105], spring individuals are of a more fiery red, and the orange band of the under surface of the hind wings is broader; while in later broods the markings are less vivid and less distinctly marked, and there is a longer tooth on the margin of the hind wings.

In our Pearl Crescent (Phyciodes Tharos) [Figs. 140, 141], according to the recent discoveries of Mr. Edwards, the spring type (which he formerly considered a species distinct from the summer

FIG. 140.—Phyciodes Tharos, summer brood, nat. size; under surface on right (Harris).

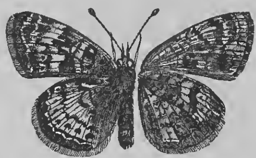


FIG. 141.—Phyciodes Tharos, spring brood, nat. size; under surface on right (Harris).

type, but which he has recently bred from the latter) is characterized by the purple or pearly hue of the under surface of the hind wings, and by heavier markings on the same wings; especially by the presence of great patches of ferruginous or dusky color at the outer margin; markings which usually are only indicated in the summer broods, where the color is delicately traced with ferruginous lines; in the spring butterflies the black markings of the upper surface are also heavier and more diffuse than in the later broods.

There is another form of dimorphism which is not seasonal, but occurs in all broods alike. The simplest form of this appears in the genus Polygonia, where it affects nearly all the species. The most conspicuous case is in the largest, the Violet Tip (Polygonia interrogationis) [Fig. 142], where the two forms were once universally considered distinct species; they differ in the brightness and

FIG. 142.—Polygonia interrogationis, nat. size (Harris.)

variegation of the lower surface of both wings, and the obscurity of the upper surface of the hind wings; but the variation affects not only almost every part of the coloring, but even the very form of the wings, as may be readily seen by an examination of the exquisite plates of Mr. Edwards' "Butterflies of North America."*

* One cannot speak in too high terms of these matchless plates. The care that has been bestowed upon them reflects the highest credit upon the author as well as upon those whom he employs.

Another striking example may be found in the Blue-eyed Grayling [Figs. 143, 144], the dimorphism of which has recently been made out by Mr. Edwards. Once the two forms, called respec-

FIG. 143.—Cercyonis Alope, nat. size ; under surface on right (Harris).

tively Alope and Nephele, were universally considered distinct species ; and not unreasonably, for they were known to inhabit partly different

FIG. 144.—Cercyonis Alope, form Nephele, nat. size ; under surface on right (Harris).

regions, Alope being a more southern and Nephele a more northern form ; there is indeed a wide expanse of territory which they inhabit in common, but with varying abundance, according to climatic conditions. The illustrations here given show well the difference between these varieties, but if they were colored, it would be even more marked.

These are examples of simple or pure dimorphism, as the others were of seasonal dimorphism; but what if we have these mixed? and what if, at the same time, we have that commingling of broods which results from premature hibernation of chrysalids? We have one conspicuous example of this complication, of such interest that it is worth while to give the history of the insect in full. It is the Zebra Swallow-tail (Iphiclides Ajax), a butterfly whose northern limits barely reach New York, and for whose history we are indebted to the perseverance of Mr. Edwards of West Virginia, whose observations have been so often mentioned here.

Fig. 145.—Iphiclides Ajax, form Walshii, nat. size.

This author has not only indisputably established the identity of two forms previously described as distinct species, but has proved the existence of a third permanent form and has admirably traced the relations of each form to the others. The scientific name of this butterfly is Ajax, which includes all the forms which it assumes; the special forms are called Walshii, Telamonides, and Marcellus [Figs. 145–147]. Each form appears at a different season of the year; Walshii is the early spring type, Telamonides the late spring, and Marcellus the summer and autumn type. Nearly all the butterflies which, in West Virginia, emerge from the chrysalis before the middle of April are Walshii; between that and the end of May, Telamonides; after this, Marcellus. The first two, however, do not appear to represent distinct *broods;* and this point, to which Mr. Edwards strangely failed to draw attention in the first account of his observations, is one of the most extraordinary features in the history of the insect; for Telamonides is not the direct conseasonal produce of Walshii, but both are made up of butterflies which have wintered as chrysalids,

Fig. 146.—Iphiclides Ajax, form Telamonides, nat. size.

those which disclose their inmates earliest producing Walshii, the others Telamonides; while all butterflies produced from eggs of the same season, and there are several successive broods, belong to Marcellus. Thus, besides the true seasonal dimorphism which distinguishes the butterflies produced from eggs of the same season from those derived from eggs of the previous season, we have a secondary seasonal dimorphism, as it may well be called, separating the earlier from the later produce of wintering chrysalids.

FIG. 147.—Iphiclides Ajax, form Marcellus, nat. size.

Mr. Edwards has shown that a portion of every brood of chrysalids, instead of disclosing the imago at the end of the ordinary time, retain it, occasionally until the appearance of a subsequent brood, but usually until the next spring. The spring brood, for which we are obliged to use the compound term Walshii-Telamonides, is therefore by no means wholly produced from chrysalids of the final brood of Marcellus, but in large measure from those of all the earlier broods, even including the earliest Walshii. Ajax, then, is at one and the same time, single, double, triple, quadruple, and, if we may trust Mr. Edwards, quintuple-brooded—a case as yet without a parallel among butterflies. The proportion of chrysalids which go into premature hibernation increases as the season advances; of those produced from eggs laid in April more than ten per cent continue until spring, from eggs laid in May about thirty-five per cent, from those laid in June from fifty to sixty per cent, and from those laid in July about seventy per cent; of course those from later eggs all hibernate. Walshii and Telamonides, then, produce Marcellus the same season, or either Walshii or Telamonides the succeeding spring. Marcellus produces itself the same season, or one of the others in the spring; neither Walshii nor Telamonides is produced the same season by any of the varieties; nor does Marcellus ever emerge from wintering chrysalids.

How difficult it has been to trace all these facts will appear from the following brief history of the species. It winters only in the chrysalis state. The earliest variety, Walshii, appears when the peach-trees bloom, about the middle of

March.* The females appear a few days later than the males, and may be found on peach, apple, and wild-plum blossoms, while the males are to be seen by the water-side or upon the road, rarely upon flowers. The caterpillars feed upon papaw, and as this tree is one of the latest in putting forth its leaves, two or three weeks elapse after the appearance of the butterflies before the young shoots of the food-plant are visible ; but no sooner do these appear than the females hasten to deposit their eggs and continue to do so until toward the end of May ; the eggs hatch in seven or eight days and the caterpillars are from twenty-two to twenty-nine days in attaining their growth. Telamonides, a later variety of the same brood, as already explained, begins to fly some weeks after Walshii, and both forms are for a time common ; the eggs of the former variety are sooner laid, and hatch in four or five days ; the caterpillars, too, mature more quickly, attaining their growth in from fifteen to eighteen days, the earlier ones often overtaking their tardier predecessors. About the first of June Walshii disappears, and before the end of the month Telamonides also ; at the beginning of this same month Marcellus appears and continues abundant through the season. The successive broods of

* Reference is made to the season in West Virginia.

this form overlap each other so as to be distinguished with difficulty; butterflies of the earliest brood continue to emerge from the chrysalis until after the first week in July, while those first disclosed lay eggs early in June, so that the earliest individuals of the second brood of Marcellus appear as soon as some belated individuals of the first brood; the attempt to trace the sequence of the broods is therefore hopelessly bewildering; and we can only judge by the comparative abundance or rarity of fresh individuals that there are three or four broods of this form alone. Eggs, caterpillars, chrysalids, and butterflies may still be found together until the frosts come and destroy all except the chrysalids.

This insect is native to the Southern States, and though its range is great, it does not extend over regions of very varied temperature. Were it otherwise we might look for further variations, such as would appear when comparing northern and southern individuals. And there is reason to believe that such a complication does exist in one of our New England butterflies whose history has been partially traced.

This butterfly, the Spring Azure (Cyaniris Pseudargiolus) [Figs. 148, 149], which appears to extend from Boston to San Francisco and from Labrador to Texas, has been described under half a dozen different names, principally owing to the various forms it assumes. Some of these names have been applied to the species as it appears in California, but as our knowledge of its history in that region is exceedingly fragmentary, we will altogether overlook it, and speak of the butterfly as it exists on the Atlantic coast.

Fig. 148.—Cyaniris Pseudargiolus, male, nat. size; upper surface (Harris).

Beginning then in the south, it first appears as a blue butterfly with large distinct markings beneath; some of the males, however, are wholly brown above, while others are blue with a faint blush of white and a heavy brown border; this form is called violacea [Fig. 150]. Later in the season it appears with very delicate markings beneath; the males are now always blue above, with a dash of white in the middle of the front wing; this variety is called Pseudargiolus proper [Fig. 151].

Fig. 149.—Cyaniris Pseudargiolus, form Lucia, nat. size; under surface (Harris).

As we pass northward a change occurs in the first brood; the brown males gradually become rarer and the blue males more common. When we have reached the vicinity of Boston, we have the following conditions: First appears a blue butterfly in which the spots of the under surface are very large and often blended into great patches; and in which the males, always blue, have only a slight trace of pale color on the upper surface of the front wings; this variety is called Lucia [Fig. 152]; it appears about the middle of April, and is abundant for a month, when it begins rapidly to decrease, and by the end of May is seldom seen. The next blue butterfly to appear is one corresponding in all respects to the violacea, or first brood of the south, excepting that all the males are blue. It makes its advent during the first week in May and remains on the wing until late in June. The earliest individuals appear scarcely more than a fortnight later than the first individuals of Lucia, and therefore they cannot be produced from them. Yet as it tends in some of its variations to become like Lucia, and Lucia also varies in the direction of violacea, it is often absolutely impossible to draw any separating line between a series of the two forms collected in a single spot. There is no alternative but to suppose that just as the first brood of Ajax is dimorphic and consists of an ear-

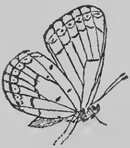


FIG. 150.—Cyaniris Pseudargiolus, form violacea, nat. size; under surface.

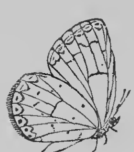


FIG. 151.—Cyaniris Pseudargiolus, form Pseudargiolus proper, nat. size; under surface.

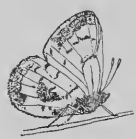


FIG. 152.—Cyaniris Pseudargiolus, form Lucia, nat. size; under surface.

lier and a later form, Walshii and Telamonides, so this blue butterfly is dimorphic in the northern part of its range, appearing as an earlier and a later form, Lucia and violacea. Additional proof will be found on tracing still farther the history of this butterfly in New England. Shortly after the appearance of violacea, or about the middle of May, we encounter another blue butterfly, too early to have been produced from violacea, just as violacea appeared too soon to have been produced from Lucia. This blue corresponds in all respects excepting size with Pseudargiolus proper of the south; and small southern individuals agree altogether with large northern examples. Now in the south Pseudargiolus has been reared from violacea; but here, the earlier individuals must be the offspring of Lucia, or the entire brood the common progeny of Lucia-violacea.

As we go still farther north, the spring brood is the only one which persists, and it is even made up entirely of the earliest New England form, viz., Lucia. At the two latitudinal extremes of its range, therefore, this butterfly appears under a totally different aspect, and has a different history. Without a study of their appearance and history in intermediate localities, no naturalist would have hesitated to class them as perfectly distinct species.

In addition to this curious polymorphism, dependent upon locality and season, there are other minor distinctions that appear to embrace all localities and seasons. As we go from north southward, or as, in any given locality where the insect is double-brooded, the season advances, we find the individuals growing larger, less heavily marked beneath, and, in the female, paler on the upper surface.

In this butterfly, then, we have a curious combination of phenomena. There is first a great difference in the aspect of the insect in widely separated localities, so that local races have been described as distinct species ; then there is simple dimorphism occurring in the spring brood in a central locality, but not at the two extremes ; a simple dimorphism partaking of a seasonal character, inasmuch as the earlier individuals of the affected brood are of one form, and the later of another ; not unlikely it will be proved that, as in the Zebra Swallow-tail, this secondary seasonal dimorphism is correlated with premature hibernation of some spring and summer chrysalids, and that the spring brood as a whole is composed of fragments of all the broods of the previous year. Besides this secondary seasonal dimorphism, we have a pure seasonal dimorphism, in the distinction of the spring and summer broods, wherever more than one exists ; and finally, in the south we have a distinct form of dimorphism in the diverse attire of different individuals among the males of the spring brood, a form of sexual dimorphism in which only a part of the males partake. To the varying forms of this kind of dimorphism attention will next be directed.

CHAPTER X.

DIVERSITY OF THE SEXES IN COLORING AND STRUCTURE.

ANTIGENY, signifying opposition or antagonism of the sexes, is a term applied to what might also be called sexual dimorphism, and embraces all forms of secondary sexual diversity, some of which will now be considered.

The partial form of sexual dimorphism, referred to at the close of the last chapter, or an antigeny affecting only a portion of one sex, is by no means rare among butterflies, but it always assumes one of two aspects, albinism or melanism; in each of these it may become universal and therefore complete. In high temperate regions albinic antigeny finds its most complete expression; toward the tropics melanic antigeny prevails; and in accord with this general statement we may observe that in the butterfly whose history was last given it is in the southern part of its range that melanic antigeny makes its appearance, that is, a part of the normally blue males become brown.

Another instance of partial melanic antigeny may be seen in our Tiger Swallow-tail [Fig. 153],

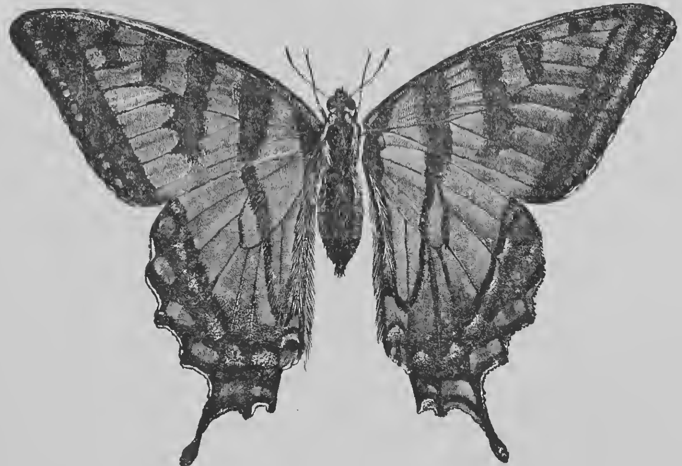


Fig. 153.—Jasoniades Glaucus, nat. size; under surface on right (Harris).

whose black female was long considered a distinct species ; and it was not until search was made for some mate to match it that suspicion was aroused. This case is the more remarkable from its being normally a gayly banded butterfly, having long black stripes on a bright yellow ground, whereas in the melanic female the yellow is quite supplanted by the black ; curiously enough, the blue flecks of the hind wing are the same in either form, the melanism having produced no effect upon them ; very rarely individuals are found in which the yellow and black are more or less commingled, and most of the melanic forms show some faint traces of the stripes in the deeper black of the parts normally covered by the black bands. Now the home of this butterfly stretches from Alaska to Florida, but north of the southern boundary of New York or thereabouts not a black female can be found ; the case is parallel in this respect with that of our little blue butterfly.

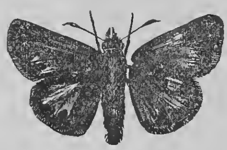


FIG. 154.—Atrytone Zabulon, female, nat. size ; under surface on right (Harris).

We have again a dusky skipper (Atrytone Zabulon) [Fig. 154], not very uncommon in New England, and still more common farther south, to which I once gave the name of Pocahontas ; for years Pocahontas sought her mate in vain, until at last we found him, united, alas ! to another wife ; a case quite like that of the swallow-tails just described ; so now we christen this twin-wived species the Mormon.

These cases might be multiplied, but we will turn rather to the albinic side. As far as I am aware, albinic antigeny occurs only in one group, the red-horns or yellow butterflies (Fugacia) ; but it appears there in several genera. In New England it is conspicuous, and must have been observed by at least every entomologist, in our common Clouded Sulphur [see Figs. 102, 103]. Here all the females differ to a certain extent from the males ; principally in having the marginal black band, which is sharply defined on its inner side in the male, ill-defined and broken by spots of the ground color in the female ; the yellow, too, is invariably somewhat paler and duller than the clear canary of the male ; this is complete antigeny. But there is also partial antigeny, for an albinic form occurs in which the yellow is altogether replaced by a dead dull white with a greenish tinge. It is a curious fact that these pale females never appear in the early spring brood, and increase in proportion as the season advances. This is in harmonious contrast with the occurrence of a melanic male in the spring brood of the azure butterfly ; when we consider that albinism is a northern, melanism a southern peculiarity, we should anticipate albinism in the cool, melanism in the hot season.

Albinic antigeny similar to that of our Clouded Sulphur may be seen more rarely in neighboring genera, south of New England; it is, however, common both in this country and in Europe to nearly all the species of the genus Eurymus, and it need not surprise us to find that in the high north and at great altitudes, species occur all whose females are pale; the colorational antigeny has become complete instead of partial. The same is the case with the melanic antigeny in many blues; there are exceedingly few species which have both brown and blue females; but brown females with blue males is a common phenomenon in Europe and in the western half of our own country.

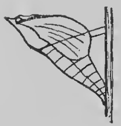


Fig. 155.—Chrysalis of Xanthidia Nicippe, nat. size.

But there is also a colorational antigeny quite apart from albinism or melanism, which may be expressed in various ways; in all such cases, so far as I know, it is complete; that is, all the individuals of one sex differ from all the individuals of the other. Such is the case in the Black-bordered Yellow (Xanthidia Nicippe) [Fig. 155]. In the male the black bordering band of the wing is sharply defined and extends across the entire outer margin. In the female the band is blurred and stops abruptly before it reaches the lower angle of the front wings, or has half traversed the

FIG. 156.—Anaea Andria, male, nat. size (Riley).

hind wings. In the skipper called Thymelicus Brettus, the female is very dark brown, almost

FIG. 157.—Anaea Andria, female, nat. size (Riley).

black, with two little yellow spots in the middle of the front wings ; while the male differs totally, being tawny with indented brown borders and an oblique black dash in the middle of the front wings ; at first glance no one could suppose them identical. In the Goat-weed butterfly [Figs. 156, 157] the male is of a deep coppery red above, bordered with dark purplish brown and blotched and powdered with the same ; the female differs in being of a lighter color throughout and in having a broad, somewhat irregular belt of a still lighter tint crossing both wings, but most conspicuous on the front pair, and brought into greater relief by a distinct edging of blackish brown. In the superb fritillary Diana (Semnopsyche Diana), the male is a rich dark brown with a very broad fulvous margin upon all the wings, marked on the front pair by one or two rows of small black spots. The female, on the other hand, is a rich purple black, with no trace of fulvous, but with the space where it belongs occupied on the front wings by three rows of white spots and dashes, and on the hind wings by two belts of blue, broken into spots, one of the belts narrow, the other exceedingly broad. In a related butterfly almost equally superb, the Regal Fritillary (Speyeria Idalia) [Fig. 158], the spots of the outer row on the upper side of the hind wings are deep orange in the male, pale bluish white in the female ; forming a striking contrast.

Again, in that charming hair-streak, the Spring

Beauty (Erora laeta), the male is wholly brown, with a border of deep blue on a portion of the hind wings; while in the female, the blue has extended so as to cover almost all the hind wings and even the base of the front wings.

But it is in the coppers [see Figs. 105, 117] that the phenomenon is most common. Here the females are usually of a fulvous color, heavily

FIG. 158.—Speyeria Idalia, nat. size; under surface on right (Harris).

spotted with black, and particularly noticeable for their conspicuous broad dark border and a row of spots crossing the wings beyond the middle; while the males are either of some dark brown shade or of a coppery fiery hue, almost always without any border or conspicuous spots.

Now in all cases of colorational antigeny it is the female and almost never the male which first departs from the normal type of coloring of the group to which the species belongs;* occasionally, however, this feminine peculiarity has been transmitted to the male, and by this means a new type of coloration established in the group. The male of butterflies is usually colored the more vividly and conspicuously, but this is not universal, as the case of the coppers, just quoted, may show. But I have seen no instance, besides that of the Spring Azure, where the male alone departs from the general type of coloring peculiar to the group. This is precisely the opposite conclusion to that which Darwin reached in his discussion of sexual selection in butterflies. He gives several examples, on the authority of Bates, which certainly favor his conclusion, but may at the same time be explained from the opposite point of view. He gives other examples from the European blues, which not only do not support, but even oppose his general statement that "the male, as a general rule, departs most from the usual type of coloring of the group to which the species belong."

Take the case of Diana, than which we could hardly find a stronger, since the group to which it belongs is remarkably uniform, exhibiting in

* A single exception to this rule among our butterflies is known to me, in the Spring Azure [see Figs. 148, 149], already referred to, in which it is the male and not the female which is sometimes brown instead of blue, the normal color of the group.

all its numerous members the same characteristic play of fulvous and black markings. The male of Diana is indeed very unlike most other fritillaries, but it retains nevertheless abundant traces of the same style of ornamentation and has precisely the same colors ; while the female departs widely from the characteristic features of ornamentation, and in addition loses every trace of fulvous, so that no one at first glance would recognize it as a member of the group.

Take again our common Sulphur Yellow and its allies [see Figs. 102, 103] ; in some species, indeed, there are only pale females ; but in others most or all of the females are yellow like the males, and any one who knows how yellow and orange tints prevail throughout the whole group to which the genus Eurymus belongs will acknowledge that the color of the males is normal.

So too with the blues, which Darwin himself quotes ; almost all of them, males and females, are of some shade of blue ; in a considerable number the males are blue and the females brown ; in only one, so far as I know, are the males sometimes brown and the females blue ; in exceedingly few both sexes are brown ; and the very fact that they are familiarly known as the "blues" is a popular recognition of the prevailing color.

In the group of skippers to which Brettus belongs [Fig. 159 ; see also Figs. 113–116, etc.], the prevailing colors, at least in the temperate zone, are certainly tawny and black or brown, the latter marginal ; this is the case with the male of Brettus, while the female diverges from the type in becoming wholly brown.

In the Tiger Swallow-tail [see Fig. 153], where we sometimes have a black female, it is more difficult to decide what should be considered the normal color, owing to diversity of view upon the relationship of many of the swallow-tails ; but to judge only from those agreed by all to be most nearly allied to it, there is no question whatever that the striped character prevails.

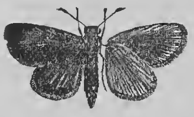


FIG. 159 —Ancyloxipha Numitor, nat. size; under surface on right (Harris).

It will be noticed in this case and others I have given that wherever partial antigeny or dimorphism is confined to one sex, it is always to the female ; and I am not aware of any exception to the rule, excepting in the case of the Spring Azure. In these instances, on my hypothesis, half of the females depart from the type ; on Darwin's, half of the females and all of the males. But if, on Darwin's theory, sometimes half and sometimes three-fourths of a species have diverged from the type, why does it never happen that only one-fourth of them diverge ? This seems to me a very pertinent and damaging inquiry.

The instances given by Darwin which strongly sustain his view are drawn from specimens of a South American genus, Epicalia, found in the rich cabinet of Mr. Bates, who travelled so long upon the Amazons. The facts as stated are these: There are twelve species of the genus Epicalia discussed; of these nine have gaudy males and plain females, one has plain male and plain female, and two have gaudy males and gaudy females. The plain females, he adds, "resemble each other in their general type of coloration, and likewise resemble both sexes in several allied genera found in various parts of the world." To examine this case fairly would need a large collection of exotic butterflies. If we confine ourselves to Epicalia we evidently cannot say whether the gaudy or the plain coloring be normal. There would be less variation from the standard on the supposition that the gaudy were the normal color; and in this case it is the female which has departed from the type; but the difference is not enough to form an objection; it is only when we look outside of Epicalia that judgment seems to lean toward Darwin's side; but, from the total want of material, I cannot fairly discuss the point, and can certainly see no flaw in his argument.

Take, however, a case which appears to be somewhat parallel, our native coppers, we have one species in which both sexes are fiery red [see

Fig. 105] marked with black; another where both are fulvous, marked with black; others where both sexes are brown, and several where the male is brown marked with fulvous, and the female fulvous marked with brown [see Fig. 117]; others, again, where the male is wholly brown and the female fulvous spotted with brown; and still others with fiery male and brown female. We have nearly every possible variation, but the prevalent feature is a dark male often with more or less metallic reflections, which sometimes increase so as to give the insect a fiery coppery hue; and a fulvous spotted and margined female. I do not see how we can discover with any certainty from within the limits of the group of coppers, what should be considered the normal type; nor are we much better off in an examination outside the group; there the prevailing tint is either brown or blue; but I am inclined to think that brown tending strongly to copper should be considered the normal type; in which case the males are generally normal, and the species antigenic.

But sexual dimorphism is not confined to color or pattern; there is also structural as well as colorational antigeny; this term embraces all those minor features which, in these and other animals, have been classed as accessory sexual peculiarities; in general, they are such characteristics as the wattles and special plumage of the cock and other birds, and, in direct opposition to the features we have been discussing, they are wholly confined to the males.

In butterflies structural antigeny is mostly confined to the wings and the legs. Sometimes it affects the contour of the wings ; one of the most conspicuous cases among our own butterflies is in the Coral Hair-streak (Strymon Titus), where the front wings of the male have a pointed tip, and the hind wings have the inner angle sharply defined ; while in the female both the tip of the front wings and the inner angles of the hind wings are rounded. Another may be seen in the two emperor butterflies represented in Figs. 182 and 184, where, besides minor differences, the hind wings of the female are full and rounded, while those of the male are angulate, the outer margin being nearly straight.

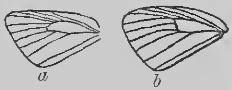


FIG. 160.—Veins of fore wing of Thecla Calanus ; *a*, male ; *b*, female ; nat. size.

Or it may affect the direction of the veins of the wings ; usually the difference between the sexes is slight and concerns the point of origin of one or two of the upper branches of the subcostal vein of the front wings ; but occasionally it is very marked, as in many of the hair-streaks [Fig. 160], where the branches of the subcostal vein near the end of the cell are thrown far out of place to accommodate a patch of peculiar crowded scales. This patch itself, moreover, is a feature of the males alone, and occurs in many hair-streaks where the position of the vein is not altered.

One of the most curious patches of this kind is found in the males of certain yellow butterflies, although wholly absent from others intimately allied to them; it is a little patch of lustreless scales which occurs at that part of the base of the hind wings which is always covered by the front wings, so that it is quite concealed from sight.

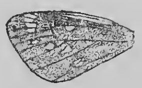


FIG. 161. — Fore wing of Thanaos Ennius, with the costal fold opened; nat. size.

Patches of a different nature also mark the male sex; thus next the middle of the lower median vein of the hind wings of the Monarch [see Fig. 106], and in some of its allies, we have a thickening and inversion of the membrane, conspicuous from its covering of black scales.

In very many males of the larger skippers (Hesperides) the front edge of the fore wing is abnormally expanded and folded compactly upon the upper face of the wing, so snugly that often it can be only discovered with the lens [Fig. 161]; moreover the scales within this fold have turned to white silken floss, which, when the fold is raised, contrasts conspicuously with the ordinarily dark surface of this part of the wing. In certain swallow-tails, also, the inner border of the hind wings is folded over in a similar though looser manner, but is so much larger that when opened it often exposes a white downy surface as large as the abdomen.

Again, there is much variety of male adornment in special modifications of hairs or scales upon the wings; the patch of the hair-streaks, just mentioned, is one instance of this; another example is found among the fritillaries in a row of long fulvous, partially erect hairs along the upper edge of the cell of the hind wings [Fig. 162]; this is accompanied by a curious apparent thickening of the veins in the middle of the fore wing, due altogether to the presence of a multitude of small and densely clustered black scales crowded against the veins at this point. A faint oblique patch of minute and crowded lustreless scales, accompanied by long silky hairs, is often seen crossing the wings of some of the satyrs or meadow-browns; but this feature finds fullest expression in the group of smaller skippers (Astyci), where a large proportion of males have a patch or oblique dash of peculiar

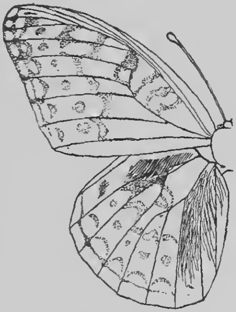


Fig. 162.—Wings of Argynnis Cybele, to show the apparent thickening of some of the veins of the fore wing, and the row of hairs near base of hind wing; nat. size.

scales covering veins and membrane indiscriminately, but usually, and in our native butterflies always, occupying the middle of the front wing and crossing the median veins obliquely near their base [Fig. 163]. This dash is variously formed, but the scales which compose it are usually much larger than the ordinary scales, are black and often partially erect; they may also differ in various parts of the patch itself and alter their character abruptly; for instance, some comparatively huge and brilliant scales may occupy the middle line and be buttressed by a multitude of minute crowded, lustreless scales; or there may be at one point a sort of whirlpool of large particolored scales, set at all angles; next it similar scales, imbricated in the most regular fashion, like the normal scales; and beyond them again a multitude of the minute, crowded, lustreless scales; these peculiarities, however, must be studied with a glass; the naked eye may indeed discover that the patch differs in different insects, but the general effect, in all alike, is a variably formed velvety patch or oblique streak of black.

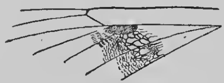


FIG. 163.—Fore wing of Thymelicus Aetna, showing the oblique patch or stigma peculiar to the males, × 2½.

Before leaving the wings, I will call attention to one striking fact. Wherever antigeny, colorational or structural, manifests itself in the wings of butterflies, the differences between the sexes almost invariably occur upon the upper surface, and generally upon the front wing only ; it occasionally happens that there is a slight difference in the general tone of color on the under surface of both sexes, corresponding to what appears above. Diana is an extreme example of this ; but it rarely affects the markings of the wings ; these are invariably similar, almost precisely similar, in both sexes, no matter what marvellous pictures nature may have drawn with her colors. The differences upon the upper surface, however, and especially upon the front wings, are, as we have seen, often conspicuous and very curious. It is hardly necessary to call attention to the fact that in moths the markings of the wings are almost entirely confined to the upper surface, and especially to that of the front wings, which in these lower groups usually cover the hind wings when in repose. This subject, however, will be more fully discussed in the next chapter.

Sexual dimorphism shows itself in the legs in the proportional length of the different pairs in the two sexes, in the special development of certain joints, in the appendages and clothing. The appendages we will not now consider, as it will be necessary, in discussing the classification of butterflies, to enter into details concerning them ; and we shall then point out how striking the antigeny becomes. As to the differences in the length of the leg-joints, I have not discovered that they follow any general law, although there are few of our butterflies whose sexes do not vary in this particular. This form of antigeny is most conspicuous in the Rurales, the family which includes most of our smaller butterflies, the blues, coppers, and hair-streaks. The males of certain coppers also present another curious feature in a tumid swelling of the basal joint of the middle and hind tarsi. Finally, the front legs of butterflies are frequently furnished with a spreading brush of hairs, or the thighs and shanks of the other legs are supplied with curious pencils or fringes of long stiff hairs, which appear to have much the same significance as similar adornments in higher animals.

Darwin supposes that all these various male appurtenances, which occur throughout the animal kingdom, such as cocks' combs, peacocks' tails, and other paraphernalia of the lords of creation, have all arisen by sexual selection; that one of rival males being selected as a mate whose outward charms are greatest. He certainly brings powerful argument and a strong array of facts to support this hypothesis. But what then shall we say of the following illustration of sexual antigeny; namely, the presence in many males among butterflies, but in *no* females, of scales of the most exquisite beauty and delicacy, scattered among the more common sort, and invisible to the naked eye. Even with the help of the microscope they can often only be discovered by ruffling the plumage and forcibly extracting them from their concealment. And so far as we can see they rarely give the wing any peculiar character by which it may be distinguished from other wings.

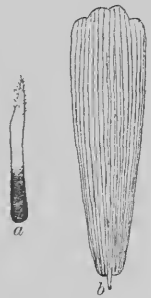


FIG. 164.—Scales of Semnopsyche Diana; *a*, androconium; *b*, ordinary scale; × 285.

These peculiar scales, or androconia as they may be termed, in reference to their masculine nature, were first noticed by Bernard-Deschamps more than forty years ago, but have never been properly studied throughout the butterflies. Deschamps called them plumules from their feathery tips; but this term is utterly inappropriate to most of them; and their form is so varied that only some word expressing their masculine character should be accepted, since this is their single common peculiarity.

These androconia are very capricious in their occurrence; a number of allied genera may possess them, while a single genus, as closely allied, may be quite destitute. This is true throughout the butterflies; and yet there are large groups in which they are altogether wanting, and others in which their absence is extremely rare. In the highest butterflies they are long, slender, and invariably feathered at the tip [Fig. 164]. In one small group they are toothed as

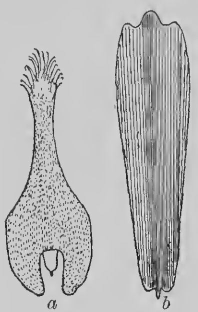


FIG. 165.—Scales of Pieris rapae; *a*, androconium; *b*, ordinary scale; × 285.

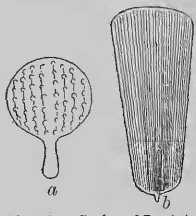


FIG. 166.—Scales of Leptotes Theonus; *a*, androconium; *b*, ordinary scale; × 785.

well as feathered. With the exception of this small group they may be distinguished from ordinary scales by the absence of any dentation at the tip. In the whites they are fringed [Fig. 165], and with a single known exception their extreme base is expanded into a sort of bulb; elsewhere, even in the other groups of the family to which the whites belong, they are not fringed, but have a smooth rounded edge. In the blues they assume

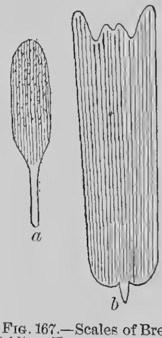


FIG. 167.—Scales of Brephidium Fea; *a*, androconium; *b*, ordinary scale; × 785.

a battledore or fan-shape, with a smooth edge, and are generally beaded and more heavily striate than the scales [Figs. 166, 167]. The same is true, but with more variations, in the coppers and hair-streaks. In the swallow-tails, where they have been supposed to be wanting, they differ very little from the scales, but are much smaller and more coarsely striate. In the skippers, where

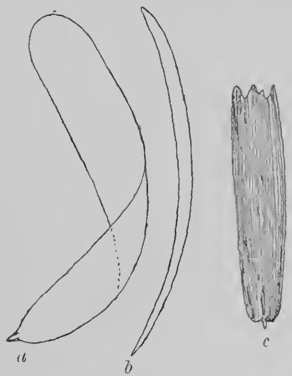


Fig. 168.—Scales of Thanaos funeralis, × 285 ; *a*, one of the large riband-shaped androconia, the striated markings of which are excessively delicate and can only be seen when magnified more than 500 times ; *b*, one of the hair-like androconia ; *c*, one of the ordinary scales.

also they have not before been noticed, they present the greatest variety in the same individual ; in one group there are hair-like androconia and others which are exceedingly large and riband-shaped [Fig. 168]; in the other group, besides hair-like and gigantic androconia, there are usually some which are spoon-shaped with long handles, or of other odd shapes [Figs. 169, 170]. As a general rule these androconia are present in the patches to which we have alluded as forming one phase of the antigenic characters of the male; but more often, as in the blues and whites, they are scattered indiscriminately, or in rows, over the upper surface of the wings; and there are many patches, like those at the base of the hind wings of some yellows and next the median vein in our Milk-weed butterfly, where androconia are not found; they do, however, sometimes occur in patches on the hind wings, as in the fold next the inner margin of the swallow-tails; but, with the exception of the discal spot of the hair-streaks, they seem to be present in all patches found on the front wings, occasionally forming the principal part of such patches, as in many yellows, and again taking no part in the display. Take, for example, the fritillaries, where so many small black scales are crowded against certain veins as to give them a thickened appearance [see Fig. 162]; the androconia are also present in great numbers, but entirely concealed; only by remov-

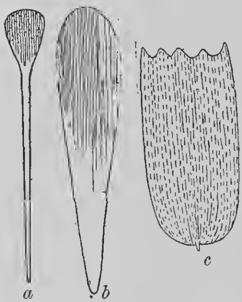


Fig. 169.—Scales of Limochores Taumas, × 285; *a*, spoon-shaped androconium; *b*, large thin androconium; *c*, ordinary scale.

ing the scales can even the tassels of their long and slender blades be seen. Perhaps even more curious than this is the arrangement by which all the

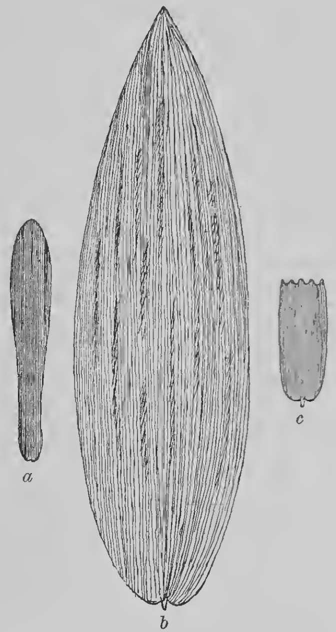


FIG. 170.—Scales of Thymelicus Aetna, × 285; *a*, club-shaped androconium; *b*, gigantic spindle-shaped androconium; *c*, ordinary scale.

androconia of the swallow-tails and of one large group of skippers are tightly inclosed in the fold of the membrane to which reference was made. It is not impossible that this fold can be opened at will by the insect, although I can hardly understand how it can be done in the skippers; and it would then become conspicuous and probably an attraction to the butterfly's mate. But what possible advantage can there be in partially or wholly concealed androconia, scattered separately over the wing? In some blues they are exceedingly scarce, numbering not more than one to a hundred scales, and the exposed surface of this not one tenth that of the scales about it. One might search an hour with the microscope over an unruffled wing and overlook it. Remember, too, that it is the merest speck of dust in a dust-heap. Does the sight of these creatures surpass our power of vision with the microscope? The theory of sexual selection, proposed by Darwin, appears to fail here, just where it should most aid us; and it seems as if we should be forced to conclude that there is a principle underlying these phenomena which may yet be found to cover both them and those which have been used in support of the ingenious hypothesis of Darwin—a law of variation for its own sake.*

* Since this was written, Fritz Müller has in various places declared these androconia to be scent-scales (Duftschuppen), having an odor presumably attractive to their consorts. That the males of many butterflies exhale odors has long been known; it is very marked in our Mountain Silver-spot (Argynnis Atlantis), which

We find, then, that antigeny or sexual dimorphism is of two kinds, colorational and structural; that the former is confined to the female, as the latter is to the male sex. Going a little farther, we may observe that the features by which females diverge from their type are those upon which specific differences are founded; while those which distinguish the males are generally such as we employ in characterizing genera. If species originate by the gradual divergence of variations once established, and if we concede, as by our argument we should, that the special characteristics of males and females in butterflies are among the most pliable, we should expect to find that the females of different species of the same genus, as well as of allied genera, agree together much more closely than the males. This we do find; and nowhere is it

has a musky smell, even perceptible long after death. But the location of the scent organs has never been properly attempted; it is idle to suppose that in so small a creature one may fix the region of the body where they belong by such rude tests as merely smelling of various parts, as Fritz Müller and his family have done. Until the odor is found to be *confined to the wings after these have been detached from the body* and separately tested, all analogy leads to the belief that they will be found upon the body proper of the insects, and probably near the hinder extremity of the abdomen. It should also be added that the attractiveness of the odor to the opposite sex has never been proven, and that some caterpillars, such as that of our White-spotted Skipper (Epargyreus Tityrus), have a distinct musky odor.

more striking than in the skippers, where antigeny of a remarkable kind, and especially structural antigeny, is almost universal.

When this chapter was written, it was my purpose to discuss still another element of permanent variation, affecting in a very striking manner the color of butterflies, and to a certain degree their form, namely, Mimicry ; but this must be deferred to another occasion, with the mere mention that there are proofs of the action of this force, even among our native butterflies. One of them in particular, the Viceroy [see Fig. 84], of which mention has often been made, departs altogether from its nearest allies to mimic the attire of another butterfly, the Monarch [see Fig. 106], differing widely in structure. But without entering into details upon this point, I trust I have already accomplished my purpose in showing that there is something more than mere external beauty in the color, design, and infinite variety of markings which make the butterfly the common type of all that is exquisite in nature.

CHAPTER XI.

THE ORIGIN AND DEVELOPMENT OF ORNAMENTATION.

Doubtless every one is aware that the patterns on the painted wings of butterflies are a sort of mosaic, formed by tiny colored scales, which by varied combinations make the most exquisite designs. The very regular arrangement of these scales may be less generally known ; for though mere specks they overlie one another as slates on a roof ; and just as figures made by the oblique arrangement of colored slates appear from a distance to have straight and not serrate borders ; so, through the minuteness of the scales, markings on a butterfly's wing, which really have ragged edges, appear perfectly uniform.

From this peculiarity of wing adornment a whole order of insects, including those popularly known as moths, millers, hawk or humming-bird moths and butterflies, was named by Linné Lepidoptera—scaly-wings. As a general, but by no means universal, rule, the lowest of these insects fly by night, those which hold a middle rank by twilight, while the highest fly almost exclusively by day. Many of the night or twilight species rest by day in exposed situations, and then cover the hind wings with the front pair, and often the abdomen by both; in such insects the upper surfaces of the front wings are marked with variegated patterns, while the hind wings and the under surfaces of both pairs are usually of a uniform brown color. Even upon the upper surface of the front wings the tints are usually very sombre, bright colors being exceptional among the moths; while in the lowest tribes there are many examples of almost uniform drab or brown coloring throughout. To this last statement, however, many exceptions could be given of insects with front wings pictured with variegated designs of such excessive minuteness that their real beauty can be appreciated only when the surface is magnified. So, too, in the large family of Phalaenidae, or gometrids, we have moths which often fly by day, and rest with all their wings fully expanded; and here the hind wings are ornamented like the front pair.

It is, however, only when we come to the butterflies, the highest Lepidoptera, that we find, as a general rule, all the wings and both surfaces highly ornamented. Even within this group we may see differences corresponding to their relative perfection of structure; for in the lowest family sombre colors prevail, and in very many instances the under surface is almost uniform in tint;

while, with the sole exception of those butterflies known as Swallow-tails (a highly specialized type of low organization), the most variegated and exquisite patterns are to be found in the highest families, and are far more generally distributed among them.

I am not aware that such a direct relation between beauty and rank has been pointed out in other groups of the animal kingdom. There can be no question of its existence here, and in an order of animals at once a synonym for all that is delicate and exquisite it is what should be expected on the theory that the lower represent earlier and the higher later forms developed from a common stock. That complicated or variegated patterns of coloring must have had their source in simpler and less varied designs, and these in slight variations from an absolutely uniform tone of color will not be denied by any who believe in the evolution of complicated structural forms from those of simpler organization ; and must be regarded as possible if not probable by all who study the past life of the globe and see the march of life, with its constant tendencies to differentiation, reaching its climax in its latest and most complex product, man.

It should be borne in mind that, as far as the direct influence of physical agencies is concerned, we are dealing here with a class of acts very different from those we meet in discussing the ornamentation of vertebrated animals. In birds and quadrupeds, the feathers, hair, and other dermal appendages have developed to maturity and even wasted and been replenished under all the vicissitudes to which animal life is exposed during a period of several years. In butterflies, on the contrary, the ornamentation we are considering is confined to the brief final epoch of life, there is no replenishing of the scale-tissue, and the scales are formed rapidly and once for all, at a definite period, viz., immediately upon the change from larva to pupa; and being then concealed from light and excesses of temperature within a thick integument, and often also behind the walls of a dark chamber of silk, vegetable fibres, or earth, they are as far removed as possible from external agencies. In the depths of this retreat the scales, including all the pigment of the wings, are completely developed, the insect appearing full-fledged and perfectly caparisoned, subject to no further change.

Nevertheless, the general phenomena of ornamentation in vertebrates are so exactly repeated in butterflies that no one can plausibly claim that these phenomena originate, in the two groups, in distinct proximate causes. The same relation of color to locality which has been so well brought out by Mr. Allen* reappears in butterflies, as I

* In various papers upon our native birds and mammals.

shall presently mention. It would, therefore, seem not unlikely that we shall be forced to discard the idea of direct physical causation in the one case as in the other. This thesis, however, it is not my purpose here to maintain. I merely wish to draw attention to the point before proceeding to discuss the origin and development of ornamentation in butterflies.

I have seen only a single attempt to trace the origin of the color-patterns of butterflies by the light of modern ideas. This was the subject of a short article by Rev. Mr. Higgins, published some years ago in the *Quarterly Journal of Science.* This writer maintains that what he terms the primary or fundamental pattern was a "pale ground with darker linear markings following the course of the veins;" and he explains its origin from the earliest monochromatic wing, by supposing that "the scales growing on the membrane upon or near the veins would be distinguished from the scales growing on other parts of the membrane by a freer development of pigmentary matter" within them. From this simple form of linear markings he would derive all those patterns which bear definite relations to the veins, such as the dark bands which cross them at an angle and are scalloped between each pair; thus he says: "a portion of the dark scales begin to diverge on each side from the veins," and "the dark lines thus formed will meet in the middle of the areas between the veins, producing a band of scallops." But all the lighter-colored and more brilliant spots he would derive from modifications in the extent and intensity of the ground-color, or, as he afterward terms it, the "blush."

It will hardly be worth while to follow his line of argument; for, plausible and simple as this hypothesis appears at first glance, it is unsatisfactory. An examination of an extensive series of specimens and illustrations convinces me that an even simpler explanation can be given, in which the darker and lighter markings have a common origin. Moreover there are definite objections to Mr. Higgins' theory. Its basis, that the scales next the veins would have a freer development of pigmentary matter within them, although perhaps true, is a pure assumption, to support which no facts are given. His observations are drawn wholly from butterflies, with no reference to the ornamentation of moths, which naturally would give some clue to the previous simpler condition of butterflies, and finally, if the earliest form of ornamentation were linear markings on a pale ground, from which the scalloped bands were derived, we ought now to find, as one form of variation, transverse series of dark spots *seated on the veins*; actually, however, while transverse series of dark spots are, next to cross-bands, the very commonest pattern in Lepidoptera, I do not know of a single instance in butterflies, and only one or two in moths, where such spots are seated upon the veins, excepting only such as occur at the extreme margin; such spots, in the body of the wing, are invariably placed *in the interspaces* between the longitudinal veins. The mode of development of eye-like spots, which Darwin has shown to be extremely simple, is also opposed to Mr. Higgins' theory, since these have their origin in a simple dark point in the interspaces, and yet give rise to some of the most brilliant colors possessed by butterflies.

We can hardly hope to obtain a rational explanation of the origin and development of ornamentation in butterflies without studying the color-patterns of the lower members of the same order. This should be our starting-point, since the mode in which the scales originate in the individual precludes, I conceive, all hope of assistance from anatomical or embryological study. We have, indeed, an especial advantage in studying the numerous living types of moths, from the fact that, as far as the hind wings are concerned, all differentiation in coloring has been greatly retarded by their almost universal concealment by day beneath the overlapping front wings. In such hind wings we find that the simplest departure from uniformity consists in a deepening of the tint next the outer margin of the wing ; next we have an intensification of the deeper tint along a line parallel to the margin ; it is but a step from this condition to a distinct line or band of dark color parallel to the margin. Or the marginal shade may, in a similar way, break up into two or more transverse and parallel submarginal lines, a very common style of ornamentation, especially in moths. Or, again, starting with the marginal shade, this may send shoots or tongues of dark color a short distance toward the base, giving a serrate inner border to the marginal shade ; when now this breaks up into one, two, or more lines or narrow stripes, these stripes become zigzag, or the inner ones may be zigzag, while the outer are plain—a very common phenomenon.

A basis such as this is sufficient to account for all the modifications of simple transverse markings which adorn the wings of Lepidoptera, and explains why, amid all the profound modifications the color patterns have undergone, the transverse style of markings holds a fundamental position ; and why such markings are far more prevalent on the outer than on the basal half of the wing, and are also so frequently scalloped. All the steps of this process, as I have explained it, apply equally well to the front wing, excepting that we cannot there so well trace the initial step in the differentiation of the primordial uniform coloring.

To carry this theory another step: By the breaking up of any one or more of these bands into spots or bars, we may conceive two new forms of pattern according as the break occurs in the interspaces or at the veins. In the former case, the tendency of dark scales to cluster along interruptions of any nature in the surface, whether veins, folds, creases, or margins, together with the concentrating force presumed in a rupture of the band, will be sure to cause the scales to collect along the veins, and, uniting with similar spots upon them, to border the vein on either side continuously. This will map the veins very distinctly upon the ground, producing in fact that condition of things which Mr. Higgins considers the primary pattern, but which, certainly, we rarely find in moths and not very commonly in the highest butterflies. Indeed, when carried to an extreme, as in the dark-veined insects with otherwise diaphanous wings, we find it only in some of the very highest moths (Aegerians and Sesiadae) or butterflies (Heliconians). The junction of these darkened veins with the darkened border of the wings produces, I suppose, the series of spots upon the tips of the veins which sometimes occur there, but, as already stated, on no other part of the veins.

If, on the other hand, the break be supposed to occur at the veins themselves, then the tendency would be to form short transverse bars, or quadrate or more or less rounded spots in the interspaces; and, finally, by a differentiation of the exterior and interior portions of a round spot, a more or less perfect ocellus would be formed. Occasionally we find long streaks of dark color down the middle of the interspaces, similar to those along the veins, produced, no doubt, by the frequent presence of a crease in such places, and the tendency of scales to follow it; the comparative weakness of such breaks in the continuity of the membrane is the reason of the comparative rarity of this form of ornamentation. The formation of ocelli has been shown by Darwin, who traced, in specimens of a South African butterfly (Cyllo Leda) a perfect gradation "from excessively minute white dots, surrounded by a scarcely visible black line, into perfectly symmetrical and large ocelli;" and instances are common in our own butterflies where one can follow a similar series onward from a uniform circular dark spot. First, a central white dot appears in it; next the whole is encircled by a light-colored halo, and so on. Darwin mentions one moth with a magnificent ocellus consisting of a black centre with eight concentric zones of colors.

Ocelli not infrequently surpass the bounds of the interspace in which they originate, but among the hundreds of ocellate specimens examined with this point in view, I have failed to find a single ocellus of a simple character which could not be definitely referred to some particular interspace. But there are other ocelli, of a complex character, such as those of the Peacock butterfly of Europe (Hamadryas Io), where, assuming it had a similar origin, we cannot possibly say where it belongs ; but in this butterfly, the other markings of the wing are seen directly through the ocelli, as through a veil ; and I believe they can be shown to have arisen in an entirely different way, by an alteration in the relative position of certain bars and spots common to butterflies of this group. No doubt all other complex ocelli, such as those with spiral annuli, could be shown, upon special study, to have originated in some similar manner.

After reaching such a stage of complication, and assuming the known tendency to suffusion of markings in butterflies, that is the blending of neighboring spots, we may easily see that, by the amalgamation of adjoining spots in different transverse rows, every conceivable pattern can be explained. There is nothing left to consider but the diversity in color itself ; and observation shows that although there are prevailing tints as well as prevailing patterns in special groups of butterflies, that nevertheless these colors are often very pliable; for instance white, yellow, and orange are readily interchangeable; and a similar reciprocal relation exists between orange and red, or between certain tones of yellow and brown.

Again, when we compare individuals of the same species, especially if of opposite sexes, the great difference between them in the profusion with which scales of metallic blue are sprinkled upon a normal dark ground shows how easily black or dark brown is replaced by metallic blue; the latter again is readily interchangeable with metallic green, or with purple or ordinary blue or green. Some instances of this interchangeability must be given farther on, and it is not therefore worth while to dilate upon it here. It should, however, be stated that the iridescence on the wings of many butterflies is of an entirely different nature, being due to a microscopic striation of the outer surface of the scales.

The hypothesis, then, of the origin and development of color-patterns in butterflies which I would maintain is based upon the scale of complication seen in the markings of living Lepidoptera, and the prevalence among them of certain special patterns. According to it, the wings first showed signs of divergence from uniformity by a deepening of the color next the outer margin, which thereafter became separated into distinct transverse bands; these bands, in breaking up, gave rise to dark-veined or to spotted wings, which served as the basis for all the variegated patterns of the present day, including ocelli, which are only specialized forms of simple interspacial spots.

This discussion leads naturally to the consideration of the intimate connection between the color-patterns and the frame-work of the wings in Lepidoptera; this relation, indeed, must be considered one of the most important features in the topography of the wings, if I may use the expression. It is seen with the first appearance of ornamentation, in the wavy outline of the transverse bands, each wave corresponding to the position of the adjacent veins. It is still more conspicuous when these bands break up into bars or spots. But its full force is shown when the patterns become most complicated, where, indeed, we should naturally expect that ornamentation would be least restrained by such limitations. The rod-like veins of the wing are often completely concealed beneath the downy covering of scales, and yet there is scarcely a spot in the wing of any butterfly whose precise position is not fixed by the nearest veins. This, however, is a very imperfect statement of the facts; to consider them fairly we must recall the general structure of the wings in butterflies. These consist, as explained more fully on an earlier page, of a thin double membrane supported by tubular rods, which extend between them and diverge somewhat like the rods of a fan. In butterflies, the number and distribution of the main rods or veins are essentially the same in the front and hind wings, although the wings themselves differ greatly in shape. Omitting details, there is a single unbranched vein in front and another behind ; while between these are two others, both branched, of which the front one (the second vein of the wing) throws out branches on both sides and the other only behind. This distribution of the veins may, for our purpose, be considered as dividing the wing longitudinally into four separate areas, each occupied by a distinct vein with its branches. The principal difference between the two wings is found in the branches of the second vein ; in the front wing the anterior branches are numerous and most of them run to the front border of the wing ; this arrangement is plainly for greater strength, the front edge of the fore wings having to bear the brunt of flight, while the front edge of the hind pair requires no such special provision, these wings in flight being practically a part of the front pair ; and they therefore have only a single front branch to the second vein terminating on the outer margin.

Notwithstanding these great differences, but in harmony with the fundamental idea in articulated animals that similar parts on successive rings should have similar structure, the markings of the two wings harmonize even to a greater extent than appears at first glance; for although there is a distinct tendency toward symmetrical repetition of markings upon the front and hind wings of a butterfly, this symmetry is not absolute, being subordinated to the distribution of the veins, and this again to the diverse needs of the two wings. The distributions of spots on these wings may therefore appear very different, when in reality they hold the same position on either, *relative to the structure.*

The number of instances in which similar markings appear in the same areas of the two wings, and in the same relative position in those areas, is far too common to be a mere coincidence; it is most readily traced in the disposition of ocelli, which are very apt to be similar in size and perfection and to be situated between the same branches of homologous veins. As one of a thousand examples of this kind, the Peacock butterfly may again be cited. On the front wing of all the butterflies of this type, the basis for a complex ocellus exists, as already remarked, in the disposition of the bars and colored patches in the subcostal area, or the area of the second vein; in the Peacock butterfly such an ocellus is formed and extends to the front margin of the wing, because the subcostal area reaches that margin. On the hind wings of these butterflies almost the only element for the formation of an ocellus is a short bar in the same area resembling one on the front wings; yet from this a complex ocellus, not so imposing as that of the front wings certainly, but still a marked ocellus, has been formed; which, true to law, just fails of reaching the front margin, keeping within the normally narrower limits of the subcostal area of the hind wing.

This distribution of the veins enables us also to point out an interesting relation between the ornamentation of the front and hinder portion of a single wing, which seems never to have been noticed, and which shows again both the strength and the weakness of symmetry. The relation of the ornamentation of the hind to the fore wing is not one of slavish repetition; indeed our ingenuity may often be taxed to discover it. But the relation of the two parts of the same wing has even less of repetition; for to a certain extent there is a polar distribution of markings. For instance, there is often a bright-colored ocellus at the inner angle of the hind wing, in the area of the fourth principal vein; should a single similar ocellus, or a bright-colored spot corresponding to it, occur in any other part of the wing, *there is only one place where it will fall*, viz., at an exactly corresponding position in the area of the first (*i.e.*, the other unbranched) vein of the wing. I do not mean there will be a corresponding spot, for one often occurs in one of these positions and fails in the other; nor that there may not be similar spots in all the areas; but that if there is a brilliant spot in the area of the fourth vein, and only one other similar spot elsewhere, the latter will fall in the area of the first vein. This is the more curious, because I do not discover the same polarity in the repetition of markings in the areas of the branching veins; here repetition is frequent, but it is far more common to find similar markings between the hinder branches of the one and of the other, or between their front branches.

Can such a play of plan in ornamentation, affecting more than our mere sense of beauty, awakening indeed in us an intellectual pleasure which does not rest upon the surface of things as a purely sensuous appreciation must do—can this be explained as purely for the purposes of the ephemeral creature itself? If it cannot; if, for instance, it is of no advantage to the butterfly that its second brilliant ocellus should occur in the area of the first rather than of the second vein, then it cannot have arisen through natural selection, without the guidance of a higher law, which has other ends for beauty than the mere survival of the creature possessing it.

The relation of the markings to the areas is still further shown in a curious way. Transverse markings, as has been said, are a predominating feature of butterfly ornamentation. If in the transverse markings of the outer part of the wing, there is a break, a sudden shift of direction, a removal, perhaps, of a fragment of a band to one side ; such a change invariably takes place, I believe, at the line of demarcation between the areas, or at one of the immediately adjacent veins ; never within the limits proper of any one area. On the front wings of the lowest butterflies we frequently find a submarginal band of spots, of which one or two are situated in the space between the adjacent branches of the second and third veins. The continuity of this otherwise uniform band is almost always broken by the shifting of these particular spots a little toward the margin of the wing. This is a single instance of which very many could be given.

It will be seen then that the relation of the markings of the wing to the disposition of the underlying framework is an important one, and actually seems to increase in importance with the complexity of the ornamentation ; so that the study of the diversity of patterns becomes an intellectual pleasure. Indeed my first appreciation of this relation arose from the necessity of describing these markings in professional work ; it was not until the minute examination which this required had forced it upon me that I learned how subservient is ornamentation to the requirements of structure, or how much reflex light was thrown by mere color patterns upon the very plan of structure itself.

In all that has been said I have only attempted to trace the probable lines along which ornamentation increased in complexity. Causes I have purposely left in the background, although I have here and there intimated that I do not believe change is wholly due either to the action of physical agencies or to natural selection. That each of these forces has borne its part in the work, there can, I think, be little doubt; but in a case like this, where we find beauty of the most exquisite and refined character in creatures of an inherently low organization, I can only express a deep-seated conviction that a preordaining purpose and plan governs these proximate causes, and that beneath both structure and beauty we may discern far-reaching and controlling thought.

CHAPTER XII.

ANCESTRY AND CLASSIFICATION.

In the history of human life nothing is more apparent than that individuals are born and perish, while families survive; families die out, while nations continue to exist; nations also have their limits, and mankind outlives them.

It is the same in the past history of life in general, revealed to us in the stony book of nature. Species come and go, while genera still maintain their ground; and, in their various times, genera, families, and orders of animals appear and disappear, while the groups higher than they outlive them. From this it follows that the existing members of any group are but the merest fragment of its true whole; and yet it is in large measure from this fragment that we must deduce the true character and relations of the group, as well as its past history. Nowhere is this more conspicuous than in the butterflies. There are probably at least ten thousand species now living; countless myriads must have enlivened the face of nature in past ages; yet only a dozen have been found in a fossil state; and these fossil remains are so recent in geologic time, and so similar in structure to existing forms, that we only seem to be carrying the present state of things a stage or two farther back, and becoming no wiser than before concerning the ancestry of the group.

Since, then, palaeontology refuses her aid, we must look within the limits of the group itself for indications of its past history. In the New Zoology, classification and ancestry go hand in hand; it is only as present structure gives us a clue to past history that it possesses much interest; and habit and modes of life have such close connection with structure that they bear willing testimony where formerly they were debarred a hearing. Our classifications are only expressions of confessedly imperfect attempts to represent the natural affinities of animals, and natural affinity is but another term for blood relationship, more or less remote. It is therefore impossible, in these days, to consider classification without assuming as a postulate that it is a present expression of a past history; and in that light no single feature is wanting in interest. In fact, nothing in nature is without its meaning, its connection with the past; and though in itself alone we may despise a senseless stupid fact, yet when it is placed beside others, with which it has harmonious relations, it becomes fruitful in meaning.

One of the most striking things we meet in studying the natural history of insects is the curious character of their metamorphoses. Those of butterflies are perhaps as complete as any, and differ widely from the transformations of the lower insects, grasshoppers for example, where the young animal is born with a very close resemblance to its parent. Has this disparity between the different tribes of insects always existed, since insects were? Or if not, what was the nature of the changes undergone by the primitive insect during its existence? And what have been the steps by which the passage has been made from homogeneous to dissimilar metamorphoses? Since the history of life everywhere shows continuous progress from a simple to a complex condition, it may be presumed that the more uniform metamorphoses of the grasshopper have preceded the more complicated changes we have discussed in butterflies. But is there in the present structure of these insects any evidence of such a presumption? The differences themselves between the caterpillar, chrysalis, and imago of the butterfly we have given in detail. The only distinction of importance between the young and fully grown grasshopper, on the other hand, lies in the absence, in the former, of wings. These are assumed during growth, and so gradually that it has been asserted there are no distinctive larval and pupal stages, as in insects generally. This, however, is a mistake; the principal difference, so far as the wings are concerned, between the early stages of the grasshopper and of the butterfly, is that in the former they are external appendages of the integument, in the latter internal (although morphologically external); in the pupal stage they are external in both, and the branching vessels that penetrate them then first assume a definite position, corresponding closely with the direction of the veins which appear in the perfect insects. It is plain that external wing-pads would greatly inconvenience a soft caterpillar, while they are of no disadvantage whatever to the young grasshopper; and that if the caterpillar state of the butterfly formerly resembled the grasshopper larva, the removal of the wings from the exterior to the interior of the body would be a natural step in the progress of the changes which have culminated in its present condition.

In the lower insects, like grasshoppers, there are throughout life breathing pores on all the thoracic segments, even on those which bear wings. In the butterfly they are absent from the segments which bear wings, both in the caterpillar and in the imago. In both these stages, however, as has been stated, these segments bear a distinct tuft of tracheae next to the natural position of a spiracle, which can have no other meaning than that the ancestors of butterflies had spiracles on these segments, as grasshoppers do to-day. Moreover this original condition is less aborted in the caterpillar than in the butterfly, for false spiracles sometimes do occur in the larvae of the lower Lepidoptera as well as slender tubes connecting them with the tracheal tufts ; and this is exactly what we should expect, since the abortion of these parts is evidently connected with greater adaptability of the wings to their purpose ; in fact they are aborted in the caterpillar only to prepare for a more completely rudimentary condition in the perfect butterfly.

There is another feature in the early stages of a butterfly's life which still more strikingly recalls the primitive condition of its metamorphoses. One important difference between the lives of grasshoppers and butterflies is that the pupal stage of the former is active, while that of the latter is quiescent. In a previous chapter attention was called to the ocellar riband of the butterfly chrysalis [see Fig. 53], an organ which bore no special relation to the parts beneath, was partially covered by the folded antennae, and which possessed no significance whatever unless it had once been useful, presuming in its possessor an active life. Examine the eye of a grasshopper just from the egg and one will find its surface closely studded with low rounded prominences, arranged in regular rows like the surface of the ocellar riband in the butterfly chrysalis; while in the perfect stage of both these prominences have crowded together, met, and therefore assumed a hexagonal outline. This condition of the eye in the chrysalis, immature, yet at present altogether unnecessary and superficial, and partly concealed by another organ, clearly points to an earlier stage of usefulness, when it was in direct connection with the underlying parts, and when the organs now concealing a portion of it were extended and free, that is, an *active* pupal stage. But activity in the pupal stage implies something more; such differences as now obtain between the mouth-parts of the caterpillar and of the imago require a period of inactivity for their alteration; but if no such period existed, there must have been *similarity* of mouth-parts in the archaic caterpillar and imago. Was it then a biting or a sucking insect? We find nothing in the present structure of the group which answers this question, but is it not possible that the insect may have possessed a mouth, such as Lubbock describes in certain low insects, which was neither distinctly biting nor sucking, but of "a peculiar type, capable of modification in either direction without loss of utility"? Or, as Darwin writes with regard to insects in general, we have only to suppose "an upper lip, mandibles, and two pair of maxillae, these parts being very simple in form; and then natural selection will account for the infinite diversity in the structure and functions" of the mouth in all insects. If, however, we were to choose between biting and sucking, there can be no doubt that the former is the more primitive condition, since insects existed before tubular flowers.

We may then consider it probable that the metamorphoses of the ancient butterfly were of a very simple nature, and that the present alterations of form, structure, and life have been gradually induced. We have seen, even in the existing species, striking variations in form, color, and period of appearance; and in the divergence of the present metamorphoses from those of the past we have a signal proof of the same tendency to variation, and of the magnitude which it may attain; in their earliest stages these variations were probably confined to individuals, but gradually, by accretion and persistence, were impressed upon the group. We may even see proofs of the continued action of this tendency to change, of the unstable equilibrium of the present condition of things, of the pliability of structure and modes of development, in a hypermetamorphosis, as it may be called, which caterpillars undergo. The extremities of the series of transformations in butterflies are complete; nothing can be simpler than some butterfly eggs; no defect nor unfulfilled purpose can be conceived in any of the organs of the butterfly. So too in the changes from caterpillar to butterfly, what could more completely accomplish its end than the chrysalis; it is a perfect mummy. Only in the caterpillar is there any opportunity for additional change. The first step toward the formation of a new stage I believe may be seen in the differences in the appendages of immature and of full-grown caterpillars, described on an earlier page. I have not yet ascertained any common feature by which the peculiarities of the earliest stage of caterpillars may be contrasted with those of later stages, unless it be the comparative length of the appendages. But certainly no caterpillar has been examined which does not show between these stages differences in form, in the relation of parts, or in the disposition and character of the appendages, greater than occur between caterpillars of different tribes. While if we go outside the families of butterflies we shall find here and there conspicuous examples of this tendency to hypermetamorphosis, which the mere mention of the young larva of Meloe and Sitaris will recall to the mind of any entomologist. All these I conceive to be examples of the present working of the same law, which from simple transformations like those of our grasshoppers and plant bugs has produced the extraordinary metamorphoses of the butterfly.

Let me here call attention to the various paths through which new forms of butterflies may spring from previously existing species. For besides those which butterflies follow in common with all animals, there are many, which, if not peculiar to them, are, at least so far as known, more conspicuous in this group. Ordinary variation, due to unknown or diverse causes, as well as that which springs from latitudinal range and distinct climatic influence, appears in butterflies as in other creatures. In these cases we suppose advantageous variations to be perpetuated and intensified by the survival of the fittest, through the law of inheritance. In this way, by slow accretions, a species multiplies into varieties, each departing from the other and from the original type, until all become firmly fixed as species, again to undergo division. Now just as the climatic influences of latitude appear to be an important factor in the development of new forms, so the difference of the seasons may work similar alterations in double-brooded butterflies; we have merely to suppose the Zebra Swallow-tail to hibernate exclusively in the imago state, to fix the variety Marcellus as the only form that will survive; on the other hand, let the insect hibernate as now in the chrysalis and be only single-brooded, and the variety Marcellus would become extinct ; suppose again both features to hold with different sets of individuals, gradually communicating this tendency in greater and greater force to their offspring, and we should behold the spring and summer varieties changed to separate species. This is one example of a mode in which seasonal dimorphism may become an originator of new forms. It is plain that entirely similar results may follow from unequal lethargy in one brood of caterpillars, such as have been referred to in some of the fritillaries. In one instance we saw reason to believe that there were two series of individuals in a single species, more or less independent, and with a distinct cycle of changes ; very slight differences have been found between the individuals belonging to these two series ; but with complete independence we may be sure that these differences would intensify, and distinct species be formed.

Ordinary dimorphism again, or the appearance of different varieties in each brood, running through both sexes, must surely be a precursor of a division in the species ; no doubt the change is gradual, so that centuries of direct experimentation would throw no light upon the change ; but we have only to suppose each form breeding true to itself and the separation will be accomplished. In the case of the Violet-tip, we have two strikingly different forms, which may be distinguished, not only by their coloring and markings, but even by the form of the wings and the sculpture of the hard parts of the abdomen ; in fact, we have two forms, permanently distinct from each other, to which we cannot apply the name of species simply because we know they have the same immediate parentage ; we can hardly doubt that the separation of this species is nearly accomplished.

The same may be affirmed of antigeny ; we find melanic antigeny both partial and complete ; in its partial condition in our Spring Azure it grows more and more nearly perfect as we pass southward ; we see its form fixed in some species, and in others the melanic feature has been superinduced upon the male. The same is true of structural antigeny. Some species, which we can hardly doubt have had a common ancestor, scarcely differ from each other excepting in the character of their antigenic peculiarities, and this accounts for the close resemblance of the females of allied species of skippers. Origin through antigeny probably occurs with other animals, but in butterflies it must be unusually common. So too with mimicry. The Viceroy and the Red-spotted Purple are nearly identical in all their earlier stages, and yet utterly diverse in the perfect butterfly ; both must have sprung from a common source, from which the Viceroy has diverged through mimicry in its final stage.

These are only a few examples, but sufficient to show in how many ways butterflies may vary and how these variations may be appropriated for the development of species; the distinctions becoming gradually intensified into complete and permanent diversity. This is natural selection. And by the avidity with which natural selection seizes every possible variation to produce new forms, one would fairly suppose that its constant action would lead to endless variety. And if on this theory we should maintain that all existing forms of animal life have sprung from a few original sources, then we may fairly conclude that natural selection, by itself alone, would also lead to inextricable confusion, through which it would be impossible now to trace one thread of harmony. That it is not so, that the groupings and relations of structure among animals are clear to the human mind, that they present an orderly arrangement and a harmonious intercombination, which appeals to his reason, is sufficient proof that natural selection, in all its wondrous and pervading power, acts under law, a law of evolution, which is no slave to the forces of nature, but brings them into subservience to its ends, a law which is working out the plans of a Supreme Intelligence, by ways which man may apprehend, but has not yet comprehended.

Let us now return to this question of classification, in considering which we had only ascertained the probable development of butterflies from creatures similar in transformation to our grasshoppers, and inquire how they are related to other Lepidoptera. The more complicated structure, the more finished ornamentation, the more complete and open metamorphoses, and the diurnal life of butterflies place them at once higher than the moths, a position which has been universally accorded, and upon which it is not necessary to linger. Let me simply mention one characteristic, first noticed by Agassiz; namely, that the downward sloping position of the wings, almost universally assumed by moths when at rest, is very different from the erect position which the wings of butterflies then assume; and that the former resembles the position of the wings in the pupal state, while the latter differs widely.

We will attempt to draw a picture of the primeval butterfly when it has so far advanced in structure toward the tribes at present existing that it is fairly butterfly and not moth. This original form must have possessed not only most of the features of the lowest family, but also, in a nascent condition as it were, all or nearly all the characters now common to the group, or which exist under some modified form in this or that offshoot, such special peculiarities being subsequent, more individualized developments of the ancestral type.

With this clue, a careful study of the structure of each stage will give a result not far removed from the following.

The egg was globular, with flattened base, its surface nearly smooth, but covered with faint reticulations, growing more minute next the micropyle, which formed a series of five to seven kite-shaped cells arranged symmetrically around a common centre.

The caterpillar had a large, smooth, rounded head, a body composed of thirteen segments, nearly uniform in size, the first bearing above a chitinous shield, the first three a pair of horny legs, the sixth to the ninth and the last segments a pair of fleshy legs, spiracles upon all the segments except the last two, but those of the second and third in a very rudimentary condition, so as to be physiologically useless. The surface of the body was covered profusely with little papillae, from each of which sprung a minute simple hair. The new-born caterpillar, however, differed perhaps in this respect from the full-grown, in that its body was furnished with short club-shaped hairs arranged in dorsal, pleuro-dorsal, and substigmatal series, there being two appendages to a segment in the lower series, and one to a segment in the others. In short, hypermetamorphosis was already established in a simple condition.

So, too, metamorphosis was complete, and the chrysalis a perfect mummy with ensheathed limbs, its contours smooth, the head rounded, the ventral outline of the abdomen as curved as the dorsal, and the tail somewhat pointed; it was protected by a slight cocoon, and probably also secured within, in a definite position, by attachment at the tail and a girt around the middle.

The butterfly was heavy-bodied and covered with scales and hairs. The head was broad, the antennae did not encroach upon the eyes and were moderately long and clubbed at the tip; the club was about three times longer than broad and curved at the base, but not hooked at the tip; the tongue was about as long as the body, with simple inconspicuous papillae near the tip; the labial palpi were bushy and rather long, the apical joint smaller than the others, and directed forward.

The front wings were somewhat triangular, twice as long as broad, with rather a pointed apex; and the hind wings rounded triangular, of about equal length and breadth. In the neuration of the former the costal and subcostal veins, with the upper branches of the latter, were closely crowded toward the front edge, at the middle of which the costal vein terminated ; the subcostal vein ran to the outer border just below the apex of the wing and had four upper branches and one lower branch, none of them forked, the last upper branch striking the front edge just before the tip of the wing ; the median had four equidistant branches, the last branch uniting by a cross vein a little beyond the middle of the wing with the lowest subcostal branch ; the submedian ran to the inner angle and the internal was soon lost in the membrane. In the neuration of the hind wing the subcostal and median veins with their branches occupied the middle and larger part of the wing ; each divided into three branches, all, excepting perhaps the first branch of the subcostal vein, originating beyond the middle of the open cell ; the costal and subcostal veins were connate at the base, suddenly diverging when they parted, the former just reaching the costal margin, but not extending beyond it ; the submedian and internal were simple and of nearly equal length.

In coloring and pattern they might have been divided into three general types : first, those whose wings were uniformly dark brown, darker above than below ; second, those of similar appearance, but more or less enlivened in the middle with tawny above and yellow below, and having, besides, minute spots bare of scales near the centre of the wings, especially of the front pair; third, chequered species, black and white above, but below pale and sometimes washed with dashes of brown and yellow. In addition, the front wings of the male, especially in the first two types, often bore patches of peculiar, probably lustreless scales, next the base of the lower median interspace. When at rest, the wings were fully or almost fully expanded, and the places on which they chose to alight were the upper surface of leaves or the ground.

All the legs were perfectly developed, the tibiae and tarsi spined above, the latter also furnished with a pair of longer spines at the tip and middle of all the legs; the tarsi were longer than the tibia, the first joint as long as all the others, and the last supplied at tip with claws and pad and special hairs. Finally, the primeval butterfly was single-brooded and wintered in the chrysalis state.

When now we come to consider what modifications of this primeval type exist at the present day, that is, how butterflies should be grouped into their various tribes, we may venture at the outset to remark that progress in the classification of butterflies, or in the appreciation of their true inter-relationships has been grievously checked by the very charm which so often attracts men to their study. There is such a rage for their collection by amateurs, enchanted only by their exquisite beauty, that their scientific study has been largely abandoned by those who are best fitted for this work by special scientific training. The description of a large proportion of the known species, the characterizing of very many of the genera, involving in either case the designation of each such group in a system, has been done by those who without previous training in any branch of natural history commenced their career by the formation of a cabinet, continued it by the description or illustration of the new species they were able to acquire, then essayed the foundation of new genera, and all without any proper knowledge of other animals, even of those most nearly allied to butterflies. Of course such persons are quite incompetent to judge of the relative subordination of characters in the single group they examine. The result has been exactly what might have been predicted—a confusion and a contradiction in current classifications that is at war with the harmony of nature. Much is due no doubt to our comparative ignorance of the early stages of butterflies. Strange as it may seem, amateurs seldom collect, still more rarely preserve for comparative study, eggs, caterpillars, and chrysalids.

The family groups into which butterflies should be divided have been variously given all the way from two to sixteen. As the structure of the different stages becomes better known there is an increasing proof of the intimate connection of many of the groups formerly believed very distinct; and it is generally conceded by the better class of recent writers that there are only about half a dozen principal groups. My own study of their structure and transformations leads me to divide them primarily into four families:*

The Brush-footed butterflies, or Nymphales.
The Gossamer-winged butterflies, or Rurales.
The Typical butterflies, or Papilionides.
The Skippers or Urbicolae.

The family nature of the last group has never been questioned by any who look upon the butterflies as composed of more than one family; indeed their distinction from the others is so marked that some have considered the remainder of the butterflies their equivalent in value; that is, they divide all butterflies into only two families. Doubtless these skippers first separated from the common stock, and never developed to a high degree, since they still remain by far the lowest of the group, and are in many points more closely allied to some of the higher moths than they are to any other butterflies. They are peculiar for their robust body, broad head, such as we have given our archaic butterfly, hooked antennae,

* For the subdivisions of these groups, see the list at the end of this book (Appendix II.).

which are widely separated at base, great length of tongue, and the presence of a middle pair of spurs on the front and usually on the hind legs, in the former developed as a curious foliate membrane ; their eggs are broadly truncate spheres, sometimes ribbed ; their caterpillars have a large head with a very thick skull and a very contracted neck, formed of the first body segment, and bearing a corneous shield above ; their chrysalids are smooth and uniform, like the pupae of most moths, but in rare instances are pointed in front. In nearly all these features they resemble the picture we drew of the primeval type ; but in the hooked antennae and foliate appendage of the fore tibiae of the butterfly, the frequently ribbed eggs, the constriction of the neck of the caterpillar, and in the occasional projection of the head of the chrysalis, they have departed from that type, and most of these peculiarities they share with no other butterflies. The other families appear to have diverged simultaneously from each other shortly after their common separation from the skippers ; and by means of the accompanying rough diagram [Fig. 171], which, like most attempts at genealogical trees, possesses anything but artistic merit, I have attempted to exhibit the apparent relation of the different groups to each other ; the position of the main branches and their divisions is supposed to indi-

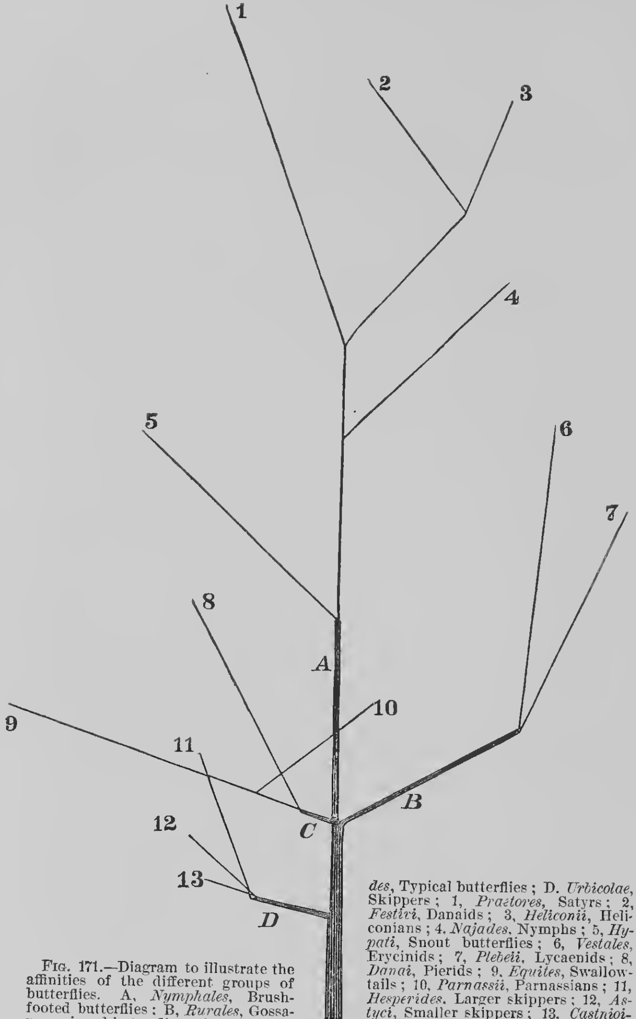


FIG. 171.—Diagram to illustrate the affinities of the different groups of butterflies. A, *Nymphales*, Brush-footed butterflies; B, *Rurales*, Gossamer-winged butterflies; C, *Papilionides*, Typical butterflies; D, *Urbicolae*, Skippers; 1, *Praetores*, Satyrs; 2, *Festivi*, Danaids; 3, *Heliconii*, Heliconians; 4, *Najades*, Nymphs; 5, *Hypati*, Snout butterflies; 6, *Vestales*, Erycinids; 7, *Plebeii*, Lycaenids; 8, *Danai*, Pierids; 9, *Equites*, Swallowtails; 10, *Parnassii*, Parnassians; 11, *Hesperides*, Larger skippers; 12, *Astyci*, Smaller skippers; 13, *Castnioides*, Castniarians.

cate, on the basis of existing affinities, the relative time at which the different groups diverged from each other or from the main stem ; and the height which each branch attains the relative perfection of the highest members of that group. It is of course impossible to represent this with any accuracy on a flat surface ; for one may properly conceive of a group only as a mass, with branches springing from a common central core. The swallow-tails and lycaenids are thus brought at opposite extremities of the tree, whereas they are closely related to each other, and disagree with all other groups in the relation of the head of the caterpillar to the segment behind it ; this relationship, however, is indicated by each occupying the lowest twig of the branch on which it is seated, both branches being closely connected at their base. The striking and unique peculiarities of certain groups is shown by their extreme divergence from the main stem ; thus the swallow-tails stand apart from all others in the possession of dorsal osmateria in the caterpillar, and in certain special characters of the butterfly, shortly to be mentioned ; the lycaenids at the opposite extreme, in the onisciform nature and diminutive heads of their caterpillars ; the castnioides among the skippers by their close approach to the moths, and the satyrs or meadow browns by the forked tail of their caterpillars. The superficial affinity of this last group to the skippers is also indicated on the diagram by the directness of their line from the very base; it is one of the most curious features in the structure of butterflies that its highest and lowest members should resemble each other in so many minor points. For instance, the tone of coloring and pattern of markings on the wings of many satyrs, as well as the position and general nature of the sexual marks on the front pair of some males, find a close counterpart on the wings of some skippers; so also the chrysalids of satyrs are among the simplest, most rounded, and compact in the whole family, approaching in this respect the lowest butterflies. Nevertheless, in all the prime features of their organization, the satyrs outrank all others or divide the honors with another small group.

It may be remarked that, with slight variations, this distribution of the groups of butterflies, founded upon the relative perfection of their organization, is generally accepted by the best investigators, and is based upon a mass of minor features which cannot be recounted here. A single exception to this statement should, however, be made in regard to the typical butterflies, whose position is the point of greatest dispute, many continuing to place them highest of all on account of the beauty and special perfection of character of a single member of that family, the group of swallow-tails. Nothing can exceed the gorgeousness of the huge Ornithoptera of the East Indies, and the most queenly of our own New England forms are its nearest relatives. They also show a unique development in the diminutive size of the palpi of the imago, in the possession of four distinct branches to the median nervure of the front wing [see Fig. 75], and in the dorsal and extreme development of osmateria in the caterpillar [see Fig. 32], to which we have already alluded. But there is no reason whatever for considering the brevity of the palpi or the extra branch of the median nervure marks of high organization, the one arising from deficiency, the other from excess of development. On the contrary, in these very points they resemble the skippers more closely than they do any other butterflies, and these features are therefore traces of their low organization. The possession of the peculiar scent-organ, however, is unquestionably a mark of high development. Wallace writes: "When we consider this singular apparatus, which in some species is nearly half an inch long, the arrangement of muscles for its protrusion and retraction, its perfect concealment during repose, its blood-red color, and the suddenness with which it can be thrown out, we must, I think, be led to the conclusion that it serves as a protection to the larva, by startling and frightening away some enemy when about to seize it, and is thus one of the causes which have led to the wide extension and maintained the permanence of this now dominant group. Those who believe that such peculiar structures can only have arisen by very minute successive variations, each one advantageous to its possessor, must see, in the possession of such an organ by one group and its complete absence in every other, a proof of a very ancient origin and of very long-continued modification. And such a positive structural addition to the organization of the family, subserving an important function, seems to me alone sufficient to warrant us in considering the Papilionidae as the most highly developed portion of the whole order, and thus in retaining it in the position which the size, strength, beauty, and general structure of the perfect insects have been generally thought to deserve." (Nat. Select., p. 135.)

It is unphilosophical, however, to accord high rank to any group for a single characteristic, and especially when in nearly all its other important peculiarities it evinces its low origin. Moreover, extensile fleshy scent organs do occur in other groups. Guenée, as we have pointed out, discovered them on the abdominal segments of the caterpillars of certain blues [see Figs. 34, 35]; and caruncles, as they are called, entirely similar to osmateria in function, general structure, and degree of development, occur in single genera of beetles, while totally absent from their nearest allies; yet nobody on that account claims for them a high rank. In the larvae of certain moths, such as Cerura, we find a much more extraordinary special development than the caterpillars of the swallow-tails can boast; the anal prolegs become long cylindrical tubes, extending backward and upward, from out of which, when provoked, the caterpillar thrusts a highly colored and banded fleshy tentacle, with which it lashes its body to frighten away intruders. Yet in other points of its structure it perfectly agrees with its kindred. Then again, if we examine the lips of the closed osmateria of the swallow-tails, we shall find them of a corneous nature, resembling no other feature in butterfly larvae than the chitinous dorsal shield on the first segment of the caterpillars of skippers. We have therefore in the very osmateria indications of a low origin, a relationship with the skippers, which most other points in the structure of the swallow-tails exhibit. The recurved club of the antenna recalls most strikingly the structure of the antennal tip of the higher skippers, and is unlike that of any other group of butterflies. The inner border of the hind wing also is folded, just as it always is in the skippers and rarely in other butterflies.

But perhaps the most striking point of affinity between these two groups lies in the possession, on the front tibiae, of the same characteristic foliate appendage [see Fig. 173], which is wanting in all other butterflies ; this, like the possession in the skippers of two pair of spines on the hind tibiae is certainly a mark of degradation, by which they are allied to the lower families of Lepidoptera. We find therefore that in the very peculiarities of their structure wherein they depart from the higher butterflies, they are most closely related to the skippers.

But, again, the swallow-tails are universally conceded to be so closely allied to the white and yellow butterflies that they are invariably placed next them. Consequently, if the swallow-tails are placed highest in the scale, the yellows must go with them ; nobody questions this ; yet the yellows possess not a single one of the characteristics by which a high rank is claimed for the swallow-tails ; commentary upon this is needless.

Having thus in a general way attempted to exhibit by the diagram the relationship and relative perfection of the different types, reducing them primarily to four larger groups, we may, through several features in their structure and habits, prove the general correctness of our estimate, by tracing a regular progression in passing from the lower to the higher butterflies. These features indicate with little doubt the progress of events in the geologic history of higher lepidopterous life, and leave a record of advance which is completely falsified by removing the swallow-tails to the summit of the order. Attention has recently been drawn to one of these features by Bates, who at the same time has proposed one of the most rational systems yet advanced; it has, however, been known and used in dividing butterflies since the time of Linné and Geoffroy. I refer to the structure of the front legs, where fundamental distinctions occur among butterflies. In the lowest family, or skippers [Fig. 172], as in the moths, all the legs are developed to an equal extent; they only differ in proportional lenth; in the swallow-tails [Fig. 173]

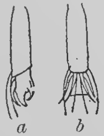


Fig. 172.—Last tarsal joint and appendages of fore leg of Epargyreus Tityrus, male, × 5; *a*, side view; *b*, top view.

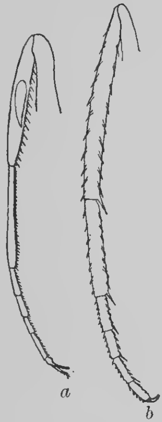


Fig. 173.—Side view of fore legs and appendages of Euphoeades Troilus, × 5; *a*, tibia and tarsus of male, showing the leaf-like appendage of tibia; *b*, tibia and tarsus of female.

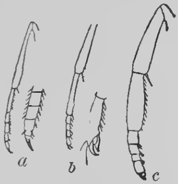


Fig. 174.—Side view of legs and appendages of Chrysophanus Thoe, × 5; *a*, fore leg of male, with tarsal joints on right still further enlarged; *b*, fore leg of female, with last tarsal joints on right still further enlarged; *c*, middle leg of male.

and in all the other members of that family this also is true. But the moment we leave these two lower families a change appears in the front legs and progresses regularly; in the gossamer-winged butterflies all the legs of the female are alike, but the front legs of the male are variously aborted, so that these insects exhibit an antigeny of a remarkable character. In the lower sub-family, to which our blues and coppers belong [Fig. 174], the tarsi of this sex have lost the terminal claw, and are densely spined beneath; even within this sub-family we can trace gradations, the claw being first replaced by a single curving spine, and then by a pair of straight spines only a little longer than the others; in the higher sub-family, the erycinids

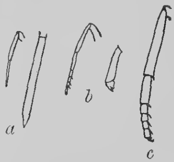


FIG. 175.—Side view of legs and appendages of Calephelis borealis, × 5; *a*, tibia and tarsus of fore leg of male, with tarsus on right still further enlarged, *b*, tibia and tarsus of fore leg of female, with last joint of tarsus on right still further enlarged; *c*, tibia and tarsus of middle leg of male.

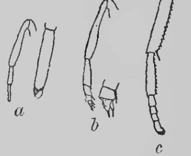


FIG. 176.—Side view of legs and appendages of Euphydryas Phaeton. × 5; *a*, tibia and tarsus of fore leg of male, with last joints of tarsus on right still further enlarged; *b*, tibia and tarsus of fore leg of female, with last joints of tarsus on right still further enlarged; *c*, tibia and tarsus of middle leg of male.

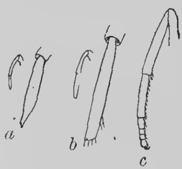


FIG. 177.—Side view of legs and appendages of Cissia Eurytus. × 5; *a*, tibia and tarsus of fore leg of male, with tarsus on right still further enlarged; *b*, tibia and tarsus of fore leg of female, with tarsus on right still further enlarged; *c*, tibia and tarsus of middle leg of male.

(Vestales) [Fig. 175], the tarsi are spineless and the joints reduced from five to one or two. In the highest family, the brush-footed butterflies [Fig. 176], atrophy of the front legs has reached both sexes, so that they are practically useless, although the atrophy is much more excessive in the male; the legs of the female are greatly reduced in size, and lack the terminal armature; while in the male of the very highest groups [Fig. 177] they are exceedingly diminutive, and the tarsi are reduced to a single minute joint. Now when we remember that this atrophy affects only the legs borne by the first segment of the thorax, and that this very segment, and this only, has become greatly reduced in size in passing from the low larval stage to the perfect form, we must accept atrophy of these legs as a conclusive mark of high organization.

FIG. 178.—Spiral tongue of Amblyscirtes vialis, showing the papillae, × 40.

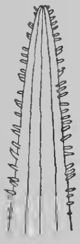


FIG. 179.—Spiral tongue of Vanessa cardui, with papillae, × 40.

If again we examine the spiral tongue we shall find, as we pass upward, a regular increase of complication in the structure of the papillae, or organs of taste. In the swallow-tails, as in the skippers (Fig. 178), these papillae are merely minute distant tubercles, situated near the tip, half a dozen or less on either side, seldom rising much above the surface. In the gossamer-winged butterflies they are longer and more frequent; while in the brush-footed butterflies [Fig. 179] the papillae are often half the breadth of the tongue in length, crowded closely together and often trifid at their tip.

Finally, how do the modes of transformation affect the question? The moths, as a general rule, pass their chrysalis stage in a cocoon of silk or earth, in which they lie loosely in a horizontal position. The skippers also always undergo their transformations in a cocoon, a light, fragile affair, it is true, but still unquestionably a cocoon; one or two other butterflies also make a slight cocoon wherein to change to chrysalis, and these few instances, such as Parnassius and Zegris, belong exclusively to the same family as the swallow-tails, though not to the same exact division. The skippers, however [Fig. 180], do not lie loosely in their cocoons as do the pupae of moths, but spin at either end a Y-shaped thread, into the centre of one of which they plunge their hooked tail, while in the upper

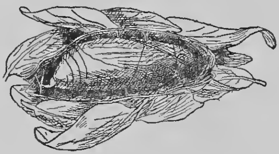


FIG. 180.—Cocoon of Epargyreus Tityrus, nat. size, the front removed to show the two Y-shaped shrouds by which it is suspended.

loop of the other they rest their body, changing the form of the upper arms of the **Y** from a **V** to a **U**. Now when we reach the next family, the typical butterflies, the cocoon, save in the exceptional instances mentioned, is lost; while the silken attachments of the chrysalis still remain, modified to suit the circumstances. Instead of the **Y**-shaped band, wherein to plunge the tail, a carpet of silk is woven upon some branch into the midst of which the hooks are thrust, while the omission of the stem of the other **Y** leaves a **U**-shaped loop or girt about the middle. To accommodate the chrysalis thus hung next a solid substance, instead of in the middle of an oval cell, the segments of the abdomen must curve upward toward the ventral line (for the chrysalis lies back downward), and thus the ventral line becomes straight, while the dorsal is strongly arched [see Fig. 139]. This condition of things is perpetuated and often intensified in the next higher family, the gossamer-winged butterflies, which differ in this respect from the typical butterflies only in the closer binding of the girt around the middle [see Fig. 58]. In the highest family, the brush-footed butterflies, the girt around the middle is lost and the chrysalis hangs suspended by the tail alone. We see, therefore, a regular progression from the lower to the higher butterflies, in the loss, first, of the cocoon, next, of the girt ; and, as if this were not enough, some of the highest butterflies (among the satyrs) have even lost the last remnant of silk and fallen to the ground, where, amid stubble or in crevices in the ground, they undergo their transformations without more ado. As if, moreover, to show that this suspension of the chrysalis by the tail alone is a stage beyond that of hanging by tail and girth, we have a clear proof that all the Suspensi, as Boisduval happily calls them, have passed through the stage of the Succincti, since *the straight ventral surface of the abdomen* [Fig. 181 ; see also Figs. 54, 57], assumed perforce by the Succincti, when they left the cocoon stage and became attached to hard surfaces, *still remains in the chrysalis of the brush-footed butterflies*, where it no longer serves any purpose ; as clear and striking an indication that the Suspensi outrank the Succincti, as that the pupa is higher than the larva.

Fig. 181.—Chrysalis of Polygonia interrogationis, nat. size.

What sort of arguments were formerly used by a certain class of speculative philosophers may be judged from the following passage published forty-five years ago : "The chrysalis of the [true] butterfly, the pre-eminent type of annulose animals, is fixed with its head *upward*, as if it looked to the pure regions of heaven for the enjoyment it is to receive in its last and final state of perfection; but the chrysalis of the brush-footed butterflies, whose caterpillars are stinging, is suspended with the head *downward* to the earth, thus pointing to the world, as the only habitation where its innumerable types of evil are permitted to reside; or to that dark and bottomless region, where punishment awaits the wicked at *their* last great change."*

* Swainson, Geogr. and Class. Anim., p. 248. London, 1835.

CHAPTER XIII.

GEOGRAPHICAL DISTRIBUTION. THE COLONIZATION OF NEW ENGLAND.

The four great families of butterflies are found in every quarter of the globe. All are represented even on the inhospitable shores of Labrador and in the accidental fauna of the South Sea Islands. They are, however, very unequally represented in every distinct zoological province, and some of the minor groups are peculiar to one or more of such regions. The most striking general feature in the distribution of the larger groups is the almost exclusive restriction of the sub-family of Erycinids to tropical America, quite as prominent a fact as the similar limitation of humming-birds to the same region. The species of humming-birds are the smallest of their class and number nearly four hundred, or about four per cent of the known birds; they are exclusively American, and more than ninety per cent of them are confined to the tropics. The Erycinids are among the smallest of butterflies and number nearly eight hundred species, or about ten per cent of the known butterflies; of these only thirty species, or less than four tenths of one per cent of the family, are found in the Old World, and of the American species ninety-seven per cent are confined to the tropics. Only six humming-birds, and similarly but seven Erycinids, are known within the limits of the United States.

All the families of butterflies are infinitely richer in specific forms within the tropics than in the temperate zones, and the Gossamer-winged butterflies and the Skippers much more richly in the New than in the Old World. The highest family, or Brush-footed butterflies, is perhaps more numerous than any of the others, and though, like them, it reaches its maximum of development within the tropics, its numerical superiority is most evident in temperate zones, and especially in the north temperate region of the Old World, where its numbers equal those of all the other families combined.

In this respect we shall find a great difference between the European and the eastern North American butterflies. Writers, in comparing the insects of these two regions, have usually called attention to their similarity; and since these regions are embraced between the same isothermal lines and nourish the same cereals, we should naturally look for a great resemblance. But if we omit from each the extreme southern species we shall find, first, that eastern America is poorer than Europe, having about one fifth less butterflies; again, while half of the European butter-

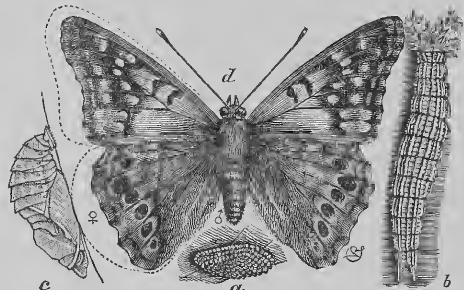


FIG. 182.—Chlorippe Herse; *a*, eggs; *b*, caterpillar; *c*, chrysalis; *d*, upper surface of male butterfly; the dotted line at left indicates the contour of the wings of the female; nat. size (Riley).

flies are Brush-footed butterflies [Figs. 182–185], less than one third of the American* butterflies

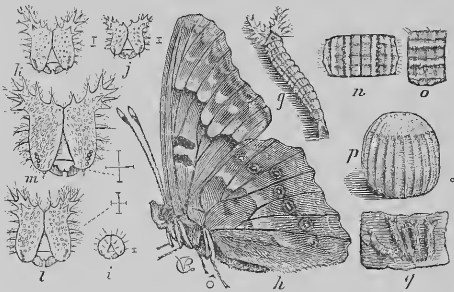


FIG. 183.—Chlorippe Herse; *g*, half-grown caterpillar; *h*, under surface male butterfly; *i–m*, the heads of caterpillars from first to fifth stage enlarged (the lines at the side indicating their real length); *n*, *o*, top and side view of one segment of caterpillar; *p*, egg, × 20, the natural size at right; *q*, caterpillars of the size at which they hibernate (Riley).

* By American, in this and the following places, I mean North America east of the Great Plains.

belong to this family. The Gossamer-winged butterflies [Figs. 186, 187] are also proportionally a little less abundant in America than in

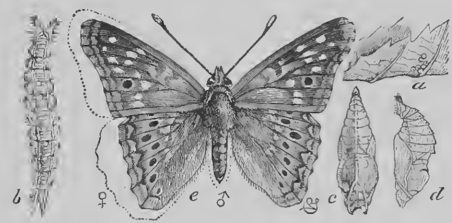


FIG. 184.—Chlorippe Lycaon; *a*, eggs on under side of leaf; *b*, caterpillar; *c*, *d*, chrysalis; *e*, upper surface of male butterfly; the dotted line at left indicates the contour of the wing of the female; nat. size (Riley).

Europe, while the Typical butterflies are slightly more abundant. The balance on the American

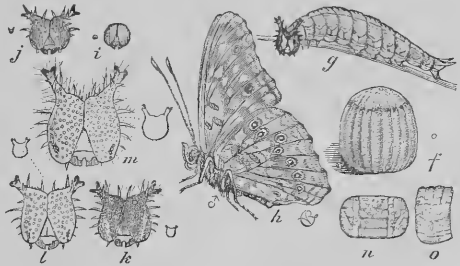


FIG. 185.—Chlorippe Lycaon; *f*, egg, nat. size and × 18; *g*, caterpillar; *h*, under surface of male butterfly; *i–m*, the heads of caterpillars from first to fifth stages, nat. size and magnified; *n*, *o*, top and side view of one segment of caterpillar, enlarged (Riley).

side, however, is made up in the lowest family, since nearly one third of the American fauna is composed of Skippers [Fig. 188], while scarcely more than one tenth of the European fauna is composed of this family. As contrasted with each other, then, Europe is peculiar for its wealth in Brush-footed butterflies, America in Skippers.

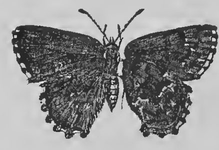


FIG. 186.—Incisalia Niphon, nat. size; under surface on right (Harris).

The disparity of representation is rendered more striking when we compare the minor groups. We will not here enter into many details, but only point out the following facts: first, that the great disparity of numbers in the Brush-footed butterflies on the two continents is almost wholly due to the vast number of Satyrs or Meadow-browns in Europe—it has seventy-seven species while we have but nineteen; second, that the preponderance of Skippers in this country is due to the great proportion of the Astyci or smaller Skippers [Fig. 189], which number forty-four with us, against nine in Europe; third, that while the Hair-streaks are twice as numerous in America as in Europe, the

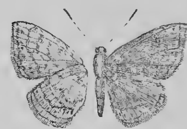


FIG. 187.—Calephelis borealis, nat. size; under surface on left.


FIG. 188.—Thorybes Pylades, nat. size; under surface on right (Harris).

balance in the sub-family is more than restored by the superior number of Blues in Europe, where there are thirty-eight species to our thirteen ; fourth, that while the numbers of the Typical butterflies on the two continents are almost equal, there is no similarity of representation in the groups composing the family, excepting in the Whites ; for the Orange-tips (Frugalia) number seven in Europe and two in America, the Yellows ten in Europe and twenty in America, the Swallow-tails [Fig. 190] three in Europe and nine in America, and the Parnassians (Parnassii) six in Europe and none in America.

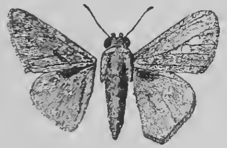


FIG. 189.—Euphyes Metacomet, nat. size ; the left side represents the upper surface of the male ; the right the upper surface of the female, attached to the body.

Notwithstanding such striking contrasts, there are many apparent resemblances ; but upon analysis nearly all of these disappear. Take, for example, the two most striking cases, the Angle-wings and the larger Skippers [Fig. 191], in both of which the numbers are the same in the two countries ; in the latter only two of the eight American and four European genera are common to both countries, and in these two the representation is very unequal, one genus having six species in America against two in Europe, and the other fourteen in Europe and two in America.

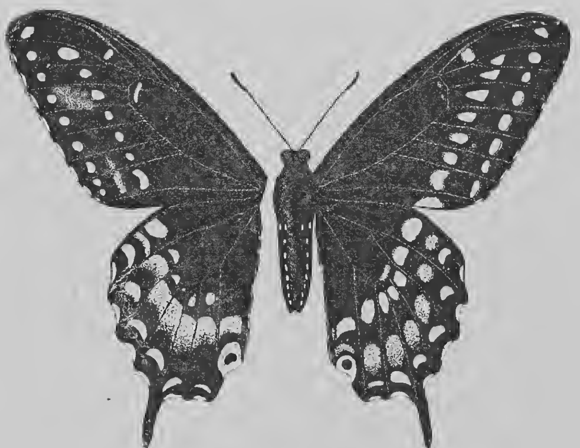


FIG. 190.—Princeps Polyxenes, nat. size; the left wing represents the upper surface of the female; the right the upper surface of the male, attached to the body.

In the Angle-wings there are eight genera, of which four are represented on each continent, the others being equally divided between the two countries. We have in this instance a closer resemblance than in any other group of butterflies, because its genera are mainly genera of the north temperate zone; and a careful study of all other points of resemblance between the two countries

Fig. 191.—Epargyreus Tityrus, nat. size; under surface on left.

will show that they are almost all confined to groups which are boreal in their aspect; while, if we had excluded from the comparisons the species inhabiting in either country the high north, and had included those of the extreme south, not only would the number of species in either country have been considerably augmented, but the resemblances would have been greatly diminished, and the differences more than proportionally increased.

It will be evident from what has been stated that a considerable portion of the present butterfly fauna of the eastern United States has been derived from the north, and a still greater portion from the south. If we are to judge of the derivation of the present fauna by the geographical distribution of its nearest allies, we shall come to no uncertain conclusions. Omitting from consideration such species as belong properly to the extreme north or south, and the few species believed to have been introduced, there will be left about one hundred and forty, which may be considered the foundation of the fauna, including nearly twenty genera peculiar to it. A careful study of the affinities of these one hundred and forty species shows that more than three-fourths of both genera and species have their nearest allies in the south, mostly in Mexico and Central America. Nearly all of the remainder belong to genera represented around the entire temperate zone of the northern hemisphere. Excepting those which are closely connected either with European or with Western American species, I do not recall a single genus peculiar to the region, unless it be Feniseca, one of the Coppers, which is unique. We may therefore conclude that our fauna is in no respect endemic, and that by far the greater part of it was derived from the south.

We are thus led from a consideration of the structure and relationship of the present butterfly inhabitants of New England and the neighboring region to the same conclusion to which the recent geological history of the country would force us. The great glacial sheet which covered the land was no fit residence for butterflies; but many sorts, companions of the cold, which it had driven southward in its advance from the pole, hugged its southern boundaries in the Middle States, and when this huge continental glacier commenced slowly to retreat, they too were driven back to their ancient sporting grounds, by the too fierce heat of the summer's sun and the parching of their food, the plants which love the snow. Others followed at a more cautious distance, and of these insects perhaps a fourth of our fauna is composed. That this is a true history appears from many facts, but from none more curiously than the presence, on the summit of Mount Washington, of a fragile butterfly [Fig. 192], whose home is there limited to a few acres of ground, but which occurs again two thousand miles away, on the alpine summits of the Rocky Mountains, and is represented at half that distance, in the north, by another butterfly, doubtless descended from the same ancestor at no very remote epoch.

A recent writer in the *American Naturalist*, Mr. Grote, has drawn a picture of the way in which, like many plants peculiar to the same alpine heights, it was left behind on the retreat of the glacial covering of the continent. "Year after year," he says, "the great glacier retreated farther and farther north, followed by the main body of its train, plants, butterflies and animals, the while some of these foolish butterflies were beguiled by the shallow ice-rivers, which then

FIG. 192.—Oeneis semidea, nat. size ; the under surface on right (Harris).

filled the ravines of Mount Washington. Return became at length impossible. They advanced behind the descending local glaciers, step by step up the mountain-side, pushed up from below by the warm climate, which to them was uncongenial, until they reached the mountain-peak, now bare of snow in the short summer. Here, blown sidewise by the wind, they patiently cling to the rocks. Or, in clear weather, on weak and careful wing, they fly from flower of stemless mountain pink to blueberry, swaying from their narrow tenure of the land. Drawn into the currents of air that sweep the mountain's side they are forced downward, to be parched in the valleys below. Yet they maintain themselves. They are fighting it out on that line."

That the great bulk of our fauna, however, is composed of southern types is evident, and may be explained by the direction of the mountain chains, which form no barrier to the northward march of animals; while our poverty, as compared with Europe, may be due to the form of the continents themselves, the tropical lands of America being scattered about among islands, or connected with the northern temperate zone by a very narrow isthmus; while Europe, on the other hand, has easy connection with all parts of the Old World.

APPENDIX I.

INSTRUCTIONS FOR COLLECTING, REARING, PRESERVING, AND STUDYING.

HAPPILY the time is past when butterfly-collectors devote their entire attention to the perfect insect. They at least rear them from the caterpillar or chrysalis to obtain fresher and more beautiful specimens for their cabinets; and it is to be hoped that any young enthusiasts who may read this book will be quite as ready to collect, preserve, and study their earlier stages as the full grown insect. It therefore needs no apology from me in giving here more space to instructions concerning the pursuit of the immature than of the mature form.

The best method of raising butterflies is to obtain eggs from the parent and rear them to maturity. This is by no means difficult and is full of interest; it is only necessary to know the food plant of the caterpillar—and that of nearly all our northern species is ascertained;* or if it is not known, it may often be inferred from that of neighboring species, or discovered by patiently following the female as she flits from leaf to leaf, and noticing the plants she chooses whereon to lay her eggs. The butterfly generally selects the middle of the day for this duty, but the eager youth must not expect at once to obtain her secret, for he will find himself only too often foiled. Once known, the way is comparatively easy; catch a female, selecting for the purpose one which has evidently been flying for at least a few days, and which is

* A list of the foot plants of such species as are mentioned in this book is given in Appendix II.

gravid with eggs, and inclose her beneath a gauze covering upon the growing plant. If it be a tree or bush, tie a muslin bag over a bough, taking care that there are some tender leaves upon it (and no ants), and so arrange the bag that the butterfly may rest naturally upon them; inclose the butterfly and she will pretty certainly deposit eggs in the course of a day or two. Or, if the plant be one of small size, use a headless keg, covered at one end with gauze; even a discarded vegetable can will serve the purpose.

After a day's or two days' confinement, the prisoner should be set free. If she has not then laid eggs, she probably cannot, and she should be released. If she has yielded the desired harvest, she should be rewarded with liberty. When obtained, the leaves or twigs upon which the eggs are found may either be left where they are or carried home to more convenient quarters.

It is not easy to preserve eggs entire. If they do not hatch they are apt to shrivel, excepting such as have a dense pellicle, like the hemispherical eggs of the smaller skippers or the echinoid eggs of the blues and coppers; it is nearly impossible, too, to prick the egg and save its form. The best way is to watch for the egress of the caterpillar and the moment it is free separate it from the shell, which it will otherwise devour; in that way I have obtained a considerable collection of these little gems. Or they may be obtained from the plants on which they have been laid naturally, by searching the food plants carefully; they are not so difficult to detect as might be supposed; many of these will be found attacked by minute parasites, which generally make their exit through a single minute hole, leaving the egg in an admirable condition for the cabinet. The eggs can then be gummed, with or without the leaf on which they are laid, upon triangular bits of card-board, pinned and transferred to the cabinet. Inspissated ox-gall, diluted with an equal quantity of thick gum arabic, makes the best material for attachment to the card.

In rearing from the egg the greatest difficulty is during early life; young caterpillars must have the freshest and tenderest food and not too much confinement. With all precautions many will be lost, for they are so small that it is difficult to keep track of them, and some are very prone to wander when their food does not suit them. Some open vessel with the growing plant is the best receptacle; in place of this a similar vessel (the larger the better) holding moist sand in which a sprig of the food plant is plunged may be used—covered if convenient with gauze to prevent the escape of the caterpillar. The vessel should be placed in the light, but not in the sun, and for many kinds it is well to lay chips or bits of bark upon the ground, beneath which the caterpillars may hide. At each moult the caterpillar remains motionless, refusing to feed for twenty-four hours or more, and at such times it should not be disturbed. It is best never to touch them, and when necessary to change the food, the old leaf with the caterpillar upon it should be put beside or upon the fresh food, and only removed when deserted by the caterpillar. When older the creature will bear rougher treatment and may often be confined in a nearly tight tin or earthen vessel with freshly plucked leaves; but all caterpillars will not bear this treatment, and care should always be taken that their quarters do not become foul.

A very convenient form of breeding cage or vivarium is shown in Fig. 193, and is thus described by Mr. Riley: "It comprises three distinct parts: first, the bottom board (*a*), consisting of a square piece of inch-thick walnut with a rectangular zinc pan (*ff*) four inches deep fastened to it above, to prevent cracking or warping, facilitate lifting, and allow the air to pass underneath the cage. Second, a box (*b*), with three glass sides and a glass door in front, to fit over the zinc pan. Third, a cap (*c*) which fits closely to the box, and has a top of fine wire gauze. To the centre of the zinc pan is soldered a zinc tube (*d*) just large enough to contain an ordinary quinine bottle. The zinc pan is filled with clean sifted earth or sand (*e*), and the quinine bottle is for the reception of the food plant. The cage admits of abundant light and air, and also of the easy removal of excrement and frass

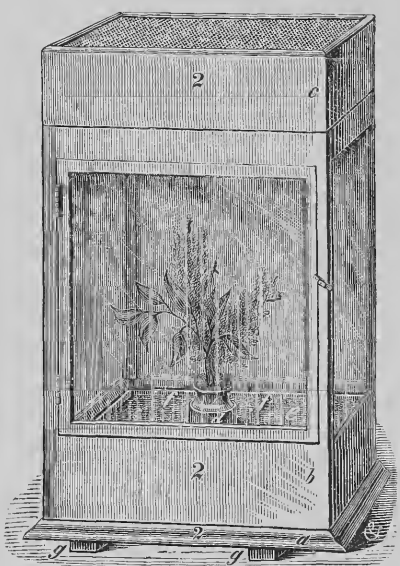


Fig. 193.—Breeding cage, described in the text.

which falls to the ground ; while the insects in transforming attach themselves to the sides or the cap according to their habits. The most convenient dimensions I find to be twelve inches square and eighteen inches high ; the cap and the door fit closely by means of rabbets, and the former has a depth of about four inches to admit of the largest cocoon being spun in it without touching the box on which it rests. The zinc pan might be made six or eight inches deep, and the lower half filled with sand, so as to keep the whole moist for a greater length of time. A dozen such cages will furnish room for the annual breeding of a great number of species, as several having different habits and appearance, and which there is no danger of confounding, may be simultaneously fed in the same cage."

The best success will always attend efforts to place the prisoner in conditions as nearly natural as possible ; but in rearing out of doors it is more difficult to keep track of your charge, and they are of course more subject to their natural enemies, which are numerous and vigilant. Moreover it is then impossible, or nearly so, to obtain the cast-off heads of each moult, which are well to preserve for comparative study at leisure, or to complete the tangible marks of the life history of the insect.

Such caterpillars as construct nests in which to live when not feeding, and especially such as then live a great while in the caterpillar state, as for instance nearly all the skippers, are the hardest to rear satisfactorily apart from their natural homes ; they do not like to live in a dried-up house, nor to be continually wasting their energies in the construction of new ones, so that one's ingenuity is often taxed to keep them happy ; but patience and careful attention to their natural conditions will reap their reward, and I believe it is possible with care to breed any of our species in confinement. Caterpillars found partly grown in a state of nature may be reared in confinement for the rest of their lives with equal ease ; only one labors then under the disadvantage, if he cares only for the butterfly, of being rewarded for his pains only by a fine batch of minute hymenopterous parasites or a bristling fly or two. To one, however, who is interested in the entire history of these creatures, this is not altogether a loss, for he will add perchance to his stock of butterfly parasites, of which for some species many different kinds are already known.

The search for caterpillars in their haunts is often very easy, especially if their food plant, habits, and seasons are known ; to search for a caterpillar out of season is an anachronism one will not enjoy. Partly eaten leaves are one of the best guides to the discovery of caterpillars ; while such as construct nests of any sort are very readily detected, especially when the nests are so built as to expose the under surfaces of leaves, where their upper surfaces would be expected, as in the case of many of the higher skippers [see Fig. 94]. The caterpillars of the blues, coppers, etc., are perhaps the most difficult to find, because they so nearly resemble in color the surfaces on which they rest ; the same is true of the caterpillar of our common yellow butterfly ; but when one has once discovered them, and knows *how they look* in their natural situations, the search becomes much easier. Others again feed mostly by night and retire by day to the covert of dead leaves on the ground or beneath sticks, and must be sought by the aid of the lantern. Such in particular are the caterpillars of our satyrs and fritillaries.

Some caterpillars, as stated in the body of this work, pass the winter in that state, either just hatched, half grown, or nearly mature. To keep these safely through our long winter and prevent their recovering from their dormancy before food for them can be obtained in the spring, is one of the most difficult tasks. It is best, as a general rule, to place them in closed or nearly closed vessels, not too small, in a dry but cool cellar, and not to move them until their food plant is again in leaf. Mr. Edwards has succeeded well with some of those which have eaten little or nothing before going into winter quarters, by placing them through the winter in an ice-house, which would seem to be rather heroic treatment at first sight ; but in almost any other situation they are liable to rouse from their lethargy too early in the spring, the critical period, no doubt, of their life. For collecting caterpillars, pocket tin boxes are the best receptacles.

The satisfactory preservation of the caterpillar for the cabinet is far easier than is generally supposed. For anatomical purposes it is much better to dissect fresh specimens, but very much may be done with specimens that have been preserved in not too strong alcohol, or in glycerine and carbolic acid. For the study of the markings or of the external features or form, nothing equals the method known as inflation, where only the pellicle and its appendages are preserved, and which has the advantage of allowing the caterpillar to be readily placed in an ordinary cabinet beside the other forms of the creature's life ; also of preserving in their natural relations all the spines and hairs which clothe the body, and of allowing these to be studied at pleasure ; specimens preserved in any fluid, on the contrary, are difficult to handle conveniently, and their examination is unsatisfactory from the matting of the hairs and spines.

The instruments necessary for inflating are a small tin oven, a spirit lamp, forceps, a pair of finely pointed scissors, a bit of rag, a little fine wire and a wheat straw.

The oven is simply an oblong tin box, about 2½ inches high, 2½ inches wide, and five inches long ; the cover is of glass, and one end of the box is perforated by a circular hole 1¼ inches in diameter. The oven rests upon a wire standard as in the woodcut [Fig. 194]. No soldering should be used upon the oven, as it would soon be melted.

The wire should be very fine and annealed ; the best is that wound with green thread and used for artificial flowers. It should not be more than half a millimetre in diameter. [Fig. 195.]

Kill the subject by a drop of ether or by a plunge in spirits. Then placing the caterpillar in the left hand, so as to expose its hinder extremity beyond the gently closed thumb and first two fingers, enlarge the vent slightly at the lower edge by a vertical cut with the scissors ; next lay the larva either upon bibulous paper on the table, or upon soft cotton cloth held in the left

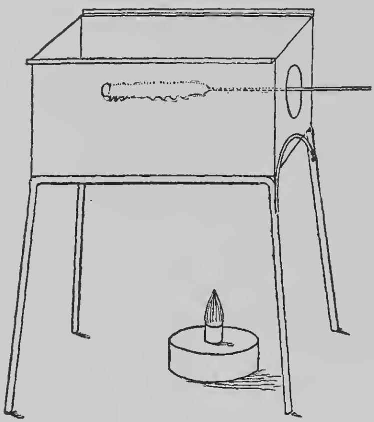


Fig. 194.—Oven and lamp for preparing caterpillars by inflation.

hand, and press the extremity of the body with one finger, always with the interposition of cloth or paper, so as to force out some of the contents of the body ; this process is continued from points successively farther back, a slight additional portion of the contents of the body being gently pressed out with each new movement. Throughout all this process great care should be taken lest the skin should be abraded by too violent pressure, and lest any of the contents of the body soil its exterior or become entangled in the hairs or spines ; to avoid the latter, the caterpillar should be frequently

Fig. 195.—Wound wire for supporting caterpillars, × 19.

removed to a clean part of the cloth. When a portion of the intestinal tube itself becomes extruded, it should be seized with a pair of strong forceps, and, the head remaining in the secure hold of the left hand, the tube should be forcibly but steadily torn from its attachments; with this most of the contents of the body will be withdrawn, and a delicate pressure passing with a rolling motion from the head toward the tail will reduce the subject to a mere pellicle.

The alcohol lamp is now lighted and placed in position beneath the oven; a wheat straw is selected, of the proper size to enter the enlarged vent, and the tip, after being cut diagonally with sharp scissors or a knife, is moistened a little in the mouth (to prevent too great adhesion of the skin to the straw) and carefully introduced into the opening of the caterpillar; the process may be aided by blowing gently through the straw. When the skin is slipped upon all sides of the straw to the distance of about a fifth of an inch, without any folding of the skin and so that both the anal prolegs protrude, a short delicate pin (Edelston and Williams, No. 19, is best) is passed through the anal plate and the straw.

By this time the oven will be sufficiently heated to commence the drying process, which consists simply in keeping the caterpillar in the oven, extended horizontally by blowing gently and steadily through the straw, as one uses a blow-pipe. Too forcible inflation will make the caterpillar unsightly by distending unnaturally any spot that may have been weakened or bruised in the previous operation; the caterpillar should be kept slowly but constantly turning, and no harm will result from withdrawing the creature from the oven and allowing it to collapse, to gain breath or rest; only this relaxation should be very brief. The caterpillar should be first introduced into the oven while inflated by the breath, and so placed that the hinder extremity shall be in the hottest part, directly above the flame, for it is essential that the animal should dry from behind forward ; yet not altogether, for as soon as the hinder part has begun to stiffen (which can readily be detected by withholding the breath for a moment) the portion next in front should receive partial attention, and the caterpillar moved backward and forward, round and round over the flame. During this process any tendency of the caterpillar to assume unnatural positions may be corrected—at least in part—by withdrawing it from the oven and manipulating it ; during inflation, the parts about the head should be the last to dry and should be kept over the flame until a rather forcible touch will not cause it to bend.

To secure the best results, it is essential that the oven should not be too hot ; the flame should not be more than an inch high, and its tip should be one or two inches from the bottom of the oven.

When the skin of the caterpillar will yield at no

FIG. 196.—Wire bent into shape to insert into the caterpillar ; not enlarged.

point, it is ready for mounting. The pin is taken from the straw, and the caterpillar skin, which often adheres to the straw, must be gently removed with some delicate, blunt instrument, or with the finger nail.

A piece of wire a little more than twice the length of the caterpillar is next cut, and, by means of forceps, bent as in Fig. 196, the tips a little incurved ; a little shellac* is placed at the distal extremity of the loop, the wire is held by the forceps so as to prevent the free ends of the wire from spreading, and they are introduced into the empty body of the caterpillar as far as the forceps will allow ; holding the loop and gently opening the forceps, the caterpillar is now pushed over

* To prepare this, the sheets of dark shellac should be preferred to the light, and dissolved in forty per cent alcohol.

the wire with extreme care, until the hinder extremity has passed half-way over the loop, and the shellac has smeared the interior sufficiently to hold the caterpillar in place when dry ; the extremities of the parted wires should reach nearly to the head. Nothing remains but to curve the doubled end of the wire tightly around a pin with a pair of strong forceps and to place the specimen, properly labelled, in a place where it can dry thoroughly for several days before removal to the cabinet.

For more careful preservation and readier handling, each specimen may be placed in a glass tube, like the test tube of the chemist. The wire is then first bent in the middle and the bent end inserted in a hole bored in the smaller end of a cork of suitable size, so as nearly to pass through it ; the loops are then formed as above ; both ends of the cork are varnished, and a label pasted around the portion of the cork which enters the tube, thus guarding both specimen and label from dust, and the latter from loss or misplacement. After two or three days the cork with the caterpillar attached is placed in its corresponding tube, and the tube may be freely handled.

Modifications of this system will occur to every one. Dr. Gemminger uses a syringe for the extraction of the contents as well as for the inflation of the emptied skin. For an oven, the Vienna entomologists employ an ordinary gas chimney, open at both ends and inserted in a sand bath, which prevents, perhaps, the danger of too great heat.

In rearing caterpillars for the after stages, seasonable care must always be taken to provide a suitable place in the breeding cage for the chrysalis to suspend itself : a twig for such as prefer such situations ; a bit of shingle near the top of the cage for those that suspend themselves by the tail, or fasten themselves preferably to flat surfaces ; leaves for those that construct some sort of a cocoon. The search for chrysalids in the open air is not likely to meet with great success excepting in a few instances, such as the imported Cabbage butterfly, whose chrysalids can be found in only too great abundance beneath palings or on the under edge of clapboards on farm houses ; those of the blues and their allies may often be found beneath stones, but one must be an enthusiast to follow the search at all successfully ; such as fall into the hands of the general entomologist must be counted as clear gain ; yet these will often repay him who studies also the parasites of butterflies, so often are they found to be infested.

The preservation of chrysalids with their colors is easy for all that are not of some green tint ; and these are few. Long-lived chrysalids are not easily killed excepting by extreme dryness. Some will survive a twelve hours' plunge in alcohol, and those that could not would generally lose some of their colors by the immersion. Dry heat is the best method, but it should be accompanied after death by further drying after an opening has been made into the body, lest the contents should decay. Parasitized specimens form the best material for the cabinet, but even shells from which the inmate has escaped can by careful manipulation and a little glue have their separated parts so joined as to answer fairly the desired purpose. Solid specimens can be pinned through one side of the thorax, but the mere pellicle should have the hooks of the tail securely fastened to a little ball of cotton wool or bit of felt, through which the pin may be passed. It is not easy to glue empty chrysalids permanently to cards, and these are very apt to hide the parts one wishes at some future time to examine. Skilful persons may attain some success with thin-skinned chrysalids, like that of the Monarch, for instance, the shape of which is difficult to retain, by removing the contents through a small opening at one side and stuffing with cotton.

The best form of net for the capture of butterflies is a bag fastened to a hoop or ring of some sort, to which a handle may be attached. The hoop should be made of galvanized iron wire, forming a circle about twelve to fourteen inches in diameter, and the bag, made of double bobbinet and attached to the wire by strong linen or cotton, should taper regularly, have a rounded bottom, and be about thirty inches long, so as to double over the net and have a few inches to spare. By bending the two ends of the wire, as in Fig. 197, they can be dropped into a brass tube and securely fixed in place by a tight plug of hard wood, leaving the other end of the tube open for the insertion of a removable handle; or a very convenient form of net can be constructed on the following plan shown in Fig. 198, and thus described by Mr. Riley: "Take two pieces of stout wire, each about twenty inches long; bend them half circularly and join at one end by a folding hinge having a check on one side (*b*). The other ends are bent and beaten into two square sockets (*f*), which fit to a nut sunk and soldered into one end of a brass tube (*d*). When so fitted they are secured by a large-headed screw (*e*), threaded to fit into the nut-socket, and with a groove wide enough to receive the back of a common pocket-knife blade. The wire hoop is easily detached and folded, as at *c*, for convenient carriage; and the handle may be made of any desired length by cutting a stick and fitting it into the hollow tube *a*, which should be about six inches long." The stick should be about four feet long. Mr. Lintner makes use of a rod with a head [Fig. 199] screwed to one end, in which to fasten an elastic brass ribbon, on which the net is drawn, but which when not in use may be placed inside the hat, while the stick serves as a cane, and the head and bag may be placed in the pocket. An entomologist becomes a less conspicuous personage with such an outfit.

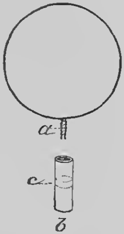


FIG. 197.—Net frame for butterflies; *a*, wire-ring, with ends bent to insert into the ferrule *b*; *c*, point where the plug and net handle meet.

The "chase" for butterflies should rarely be a question of speed ; caution and stratagem are better arts ; a butterfly should rarely be alarmed, or the game is

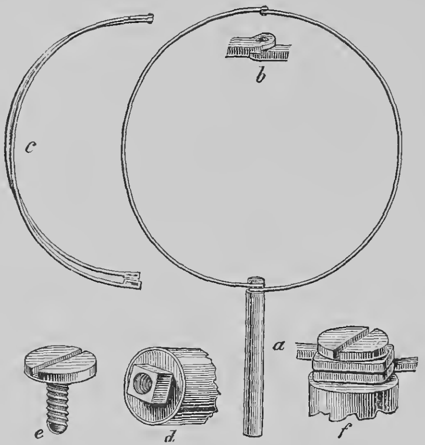


FIG. 198.—Folding net frame, explained in the text.

lost ; intent upon a flower, one may even be captured with the fingers by slow approach upon the shady side ; many have the habit of returning to a twig they have left, and can be captured by lying in wait near the spot ; others will course up and down a roadside, a forest lane, or a hedgerow, and may be easily netted by taking advantage of this habit. Nor should it be forgotten that not a few are very limited indeed in the selection of their haunts, and every kind of spot should be visited ; some confine their flight to marshy spots and even to particular bogs ; some prefer the open fields ; pastures where thistles and other weeds are in flower attract a great crowd ;

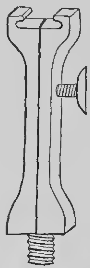


FIG. 199.—Net-head for a removable frame.

others may be found in openings in the forest where the fire-weed conceals the charred timber beneath its panicles of blue flowers; one will not look in vain upon the golden-rods and blossomed vines which fringe the roadside or stone walls; the shrubbery which loves the margin of slender streams or the edge of thickets is a favorite haunt of many; sheltered valleys with their varying verdure are always a choice resort of the entomologist; but even the tops of rugged mountains or sandy wastes given to sorrel and feeble grasses will yield their quota; the garden too, the vegetable field, and even the roadside puddles must not be neglected.

One soon learns to capture with a dexterous turn of the net, and no description of the method is worth anything beside a very little experience; when captured the net should be turned to prevent escape and the butterfly gently seized from outside the net, with the wings back to back to prevent its struggling and so bruising itself; it should then be removed to the cyanide bottle, where, especially if placed in the dark pocket, it will soon be motionless, and speedily dies; this is the quickest and easiest mode of death, besides leaving the insect in the most perfect condition. The "cyanide bottle" is simply a phial with a mouth wide enough to readily admit the largest specimens (a smaller size is better for the smaller kinds), into which a little plaster of Paris has been poured over a small lump of cyanide of potassium (a deadly poison be it noted). The cork should be removed only when necessary and for as little time as possible; a season's use will exhaust its best strength even when the utmost care is taken. Some butterflies, especially those having yellow colors, should be left in the bottle only a short time, for they are injured by too long exposure to the vapors, the yellow turning reddish. When removed, on reaching home, or sooner if needed, they should be pinned through the thickest part of the thorax, and in an hour or two, when the fixity of the wings which follows their violent death has passed away, removed to the setting board.

The best pins for butterflies are Nos. 2, 3, and 4 of Klaeger's make. The setting board needs no description apart from the figure given [Fig. 200], more than to say that beneath the groove a strip of cork or pith is attached to the board. Bits of glass cut to different sizes answer as well as the card braces represented in the illustration and permit one better to see whether the wing is lying perfectly flat. A needle inserted in a handle is required to move the wings into the desired position, and "to set" the antennae and legs in a natural attitude; to secure these in the proper place they are supported by insect pins stuck into the board upon one side or the other of the member, as required. The

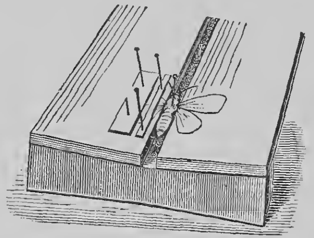
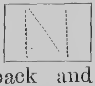


FIG. 200.—Setting-board.

butterflies should remain upon the setting board for a fortnight or longer, and placed where they will dry readily but not be exposed to dust. At the expiration of that time they are ready for the cabinet.

When one is away from home conveniences, a very simple device for transportation is to fold oblong bits of paper (rather thin writing paper is best) into "triangles" as along the dotted lines in this sketch: into this the butterfly is placed, its wings folded back to back and antennae tucked carefully away. The place, date, and circumstances of capture (or a number corresponding to a journal) may be written upon the paper. A



great number may thus be packed into a cigar box or other receptacle, and spread for the cabinet at leisure, months or even years after collection. For this purpose moistening pans are needed. A glass or stone ware dish is the best, the top ground so as to allow a sheet of glass to cover it perfectly ; upon the bottom moistened sand is plaeed, covered by fine brass wire-netting. A few papers with their inclosed butterflies are placed in it, and the cover left on for twenty-four hours or thereabouts, when the insects may be handled nearly as if just caught.

Damp, grease, and museum pests are the great destroyers of insect collections. To avoid the first, one has only to see that his cabinet is in a dry place, with a play of air around it. To avoid grease, insects should be thoroughly dried before being admitted to the cabinet, and all use of cedar wood in constructing the latter should be avoided. Against museum pests one can be safe only by a constant, vigilant, searching oversight of his collection, or the use of boxes which they cannot enter ; even then care must be taken not to introduce them oneself by placing infested specimens in the collection ; for this purpose it is well to establish a safe quarantine.

For a permanent cabinet nothing can excell the drawers made after the Deyrolle model, now in use by the Boston Society of Natural History. I have tried them for six years and find them entirely pest-proof. They are made [Fig. 201] with a cover of glass set in a frame whieh is grooved along the lower edge, and thus fits tightly into a narrow strip of zinc, set edgewise into a corresponding groove in the drawer ; the grooves beyond the point of intersection of two sides are filled with a bit of wood firmly glued in plaee ; it is hardly necessary to say that the sides of the drawer and the frame of the cover should be made of hard wood ; soft wood would not retain the zinc strip ; the zinc should be perfectly straight and the ends well matched ; if this be done nothing can enter the box when it is closed. A similar box with a wooden rabbet is used at the Museum of Comparative Zoology at Cambridge; but it cannot possibly be so tight, and requires hooks on the sides to keep the cover down; it has the advantages of greater cheapness, as it can be made of soft wood, but is at the same time clumsier. My own drawers are made of cherry sides, and have also a false front attached to them, furnished with mouldings and handles so as to present a not inelegant appearance; and, exclusive of the cork with which they are lined, cost $2.65 each;

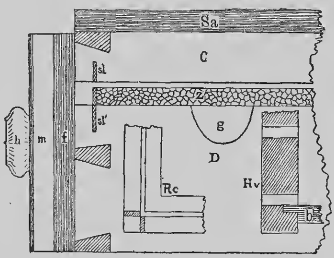


Fig. 201.—Model of the Deyrolle insect-drawer, side view of front end, with the cover raised. D, bottom of drawer; C, cover of same, raised a little; *f*, front piece, with moulding (*m*) and handle (*h*), glued to bottom piece; *sa*, sash; *sl*, slit in cover, into which the zinc strip (*z*) fits; *sl'*, slit in bottom, into which it is fastened; *g*, bevelled groove, to allow the finger to raise the cover; *Hv*, hind view of one end of the bottom to show the insertion of the bottom (*b*); *Rc*, reverse of one corner of cover to show the grooves filled beyond their junction. All the figures half size.

they measure inside $18\frac{3}{4}$ inches long, 14 inches wide, and $1\frac{7}{8}$ inches deep, not including the cork lining.

It is best always to cover the bottom of such drawers with cork or pita wood or similar soft substance, as it is difficult both to insert and to withdraw the pins readily in any ordinary wood, however soft; and the sides and bottom should afterwards be covered with thin white paper for neatness' sake.

Drawers like these are rather large for small collections, but any smaller size is wasteful of space for arranging the larger species of wide expanse of wing.

Some, however, still prefer smaller sizes for convenience of study, and use boxes shaped like a quarto volume, the cover hinged and the whole lined with binder's cloth. The volumes can then be lettered on the back and arranged as in a library, and certainly have a neat appearance. Such books can be made safer either by a bevelled wooden rabbet where the top and bottom meet, or by arranging within a second glass cover, but they can never be made so fully proof against pests as an unhinged drawer.

A very common box, but unsafe so soon as a collection becomes at all large and cannot be constantly watched in every part, is a simple wooden box nine by fourteen inches in size, in which both top and bottom, made separate, are put to use by being lined with cork. In this case the box must, of course, be much deeper. Such cases can be made in numbers for fifty cents each, exclusive of the cork, and answer very well for beginners, but will be discarded after a time if the collection increases, unless the owner has sufficient leisure and patience to watch his treasures carefully.

Insect-drawers of the modified Deyrolle pattern described above will be made, on ordering a considerable number, by Leander Greeley, 113 Broadway, Cambridgeport, Mass.

Entomological supplies, such as pins, forceps, sheet cork, blank labels, etc., may be obtained of:

John Akhurst, 32 Nassau Street, Brooklyn, N. Y.

Canadian Entomologist, London, Ontario, Canada.

The following low-priced books will be found useful to the student of American butterflies:

Packard. "Guide to the Study of Insects." 8vo. Henry Holt & Co., New York.

Harris. "Treatise on Insects Injurious to Vegetation." 8vo. Orange Judd Co., New York.

Morris. "Synopsis of the Described Lepidoptera of North America." 8vo. Smithsonian Institution, Washington.

Gosse. "Canadian Naturalist.' 12mo. London, 1840.

Gosse. "Letters from Alabama." 16mo. London, 1859.

(These works of Gosse can only be found upon occasion.)

The following existing publications of entomological societies also furnish much information :—

"Proceedings of the Entomological Society of Philadelphia," 1861–67. 6 v., 8vo. Now called "Transactions of the American Entomological Society," 1867–80. 8 v., 8vo.

"The Canadian Entomologist," 1869–80. 12 v., 8vo.

"Psyche." Organ of the Cambridge Entomological Club, 1874–81. 3 v. 8vo.

"Bulletin of the Brooklyn Entomological Society," 1878–80. 3 v., 8vo.

"Papilio ;" devoted to Lepidoptera exclusively. Organ of the New York Entomological Club. 8vo. Commenced in 1881.

Then there are many expensive works which are invaluable, of which the following may be particularly specified for their excellence or importance :—

Doubleday & Westwood. "Genera of Diurnal Lepidoptera," 2 v., fo. London, 1846–52.

Edwards. "Butterflies of North America," 2 v., 4to. New York, 1868–81. The second volume is not quite completed.

Abbot & Smith. "Natural History of the Rarer Lepidopterous Insects of Georgia," 2 v., fo. London, 1797.

Boisduval & LeConte. "Histoire Générale et Iconographie des Lépidoptères et des Chenilles de l'Amérique Septentrionale." 8vo. Paris, 1829–42.

Boisduval. "Species Général des Lépidoptères." Vol. 1, 8vo. Paris, 1836.

Hübner. "Sammlung exotischer Schmetterlinge." 3 v., 4to. Augsburg, 1806–24.

Hübner. "Zuträge zur Sammlung exotischer Schmetterlinge," 5 parts, 4to. Augsburg, 1818–37.

Cramer. "Papillons Exotiques." 4 v., 4to. Amsterdam, 1775–82, and supplement by Stoll', 1 v., 4to, Amsterdam, 1787–91.

Felder. "Novara Reise. Lepidopteren." 4to., n. d. Wien.

A convenient catalogue of the butterflies of the world is Kirby, "Synonymic Catalogue of Diurnal Lepidoptera." 8vo. London, 1871, and supplement, 1877.

For catalogues of our own butterflies see Edwards' list in the "Transactions of the American Entomological Society," vol. 6, 1877, and Scudder's lists in vols. 2 and 3 of the "Bulletin of the Buffalo Society of Natural Sciences," 1875 and 1876 ; these last include only the two higher families. See also Strecker's "Butterflies and Moths of North America," 8vo, Reading, 1878 ; and Gerhard's "Systematisches Verzeichniss der Macro-Lepidopteren von Nord-Amerika," 8vo, Berlin, 1878.

Much relating to our butterflies will also be found in the Proceedings of the Academy of Natural Sciences of Philadelphia, the Boston Society of Natural History, and the California Academy of Natural Sciences, as well as in the Bulletin of the Buffalo Society of Natural Sciences.

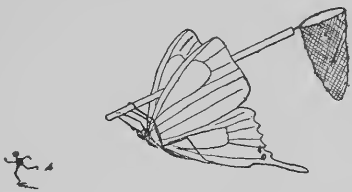
The best way to commence the study of butterflies is to attempt to follow out the life-history, write the biography in short, of every kind found in one's own neighborhood. No one place will yield much above one hundred species, and, if the rarer kinds be omitted, not nearly so many. Yet any one who will accomplish this will add materially to what is known, and he will find his way pleasanter, his occupation more fascinating at every step. He need be provided at the outset with a very moderate stock of the articles mentioned in the preceding pages. He should keep a journal devoted exclusively to a record of his daily notes, which will prove more and more useful in each succeeding year. Commencing with the eggs laid by imprisoned females or found in the open field, he should note every change which transpires, describe and, if possible, *draw in detail* every stage, giving to each separate lot a distinctive number, which it should keep until its name is known. As his stock enlarges and his knowledge increases, comparative study will supersede many of his earlier descriptions; but these will not have been without their value; they will have cost no more than they are worth; his knowledge will have been gained through, as well as at the expense of, his earlier work, none of which will he rightly regret; he can therefore be neither too minute nor too exact, nor can he afford to relax any endeavor until he has proved it unnecessary.

He should preserve in his permanent collection specimens to illustrate every condition of the creature's life, as well as all objects which illustrate its habits and vicissitudes. Especially should all variations be preserved. The egg with the leaf upon which it is laid in a state of nature; not only the caterpillar at every stage, but in all the attitudes it assumes, the nests it weaves, the half devoured leaves to show its manner of feeding, the ejectamenta, the parasites by which it is beset; not only the chrysalis, but the emptied skin; the butterflies of each brood together with some preserved in their natural attitudes when at rest, and when asleep; and such dissections of the external parts as can be separately mounted and cannot otherwise be readily seen; also the wings and body of the butterfly denuded of their scales, to study the structural framework of the insect; and, when possible, dissections of the internal parts preserved in alcohol.

Every pinned specimen, excepting such as illustrate the anatomy only, should bear upon the pin a label giving the place and date of capture, and, when necessary, a number referring to a catalogue or note book in which memoranda may be entered to any extent that is desired. The name of the species may be given on a separate label at the head of each collection of objects which illustrate its history; and the name may of course also be added at will to any specimens which once determined may require redetermination if misplaced and not specially marked.

In rearing it is essential that every breeding cage or pot should be marked with a number or by other means to indicate its contents. Nothing should be left to memory in this particular. Nor should caterpillars which are only presumably of the same species be placed in the same cage, as there are many allied kinds which are almost indistinguishable at sight, and a lack of exactitude here will vitiate one's observations.

Any one pursuing vigorously such a course of study and collection of native butterflies will be enchanted to see how fascinating the study is, how rapidly his collection grows, what an endless source of interest attaches to these humble but exquisite creatures, and into how many lines of real investigation his steps are tending. No one can undertake it without being himself the gainer by it, and without infusing others with his own ever fresh enthusiasm.



APPENDIX II.

SYSTEMATIC LIST OF BUTTERFLIES MENTIONED IN THE TEXT, WITH THEIR SCIENTIFIC AND POPULAR NAMES, AND REFERENCES TO THE ILLUSTRATIONS.

Family NYMPHALES Linné [*Nymphalidae* Steph.].
Brush-footed Butterflies.

Subfamily PRAETORES Herbst.

Tribe OREADES Borkhausen [Satyridae Swains].
Satyrs, or Meadow Browns.

Genus **Oeneis** Hübner [*Chionobas* Boisd.].

Oeneis semidea (Say). White Mountain Butterfly. (Fig. 192, butterfly.)

Genus **Cercyonis** Speyer.

Cercyonis Alope (Fabr.). Blue-eyed Grayling. (Figs. 143, 144, butterfly ; fig. 57, chrysalis ; figs. 37, 38, caterpillar—details.)

Genus **Satyrodes** Scudder.

Satyrodes Eurydice (Linn.-Johanns.) [Boisduvalii Harr.]. Eyed Brown. (Fig. 120, butterfly ; figs. 19, 36, caterpillar—details.)

Genus **Cissia** Doubleday.

Cissia Eurytus (Fabr.) [*Eurytris* Fabr.]. Little Wood Satyr. (Fig. 121, butterfly ; fig. 177, butterfly—details.)

Subfamily HELICONIDAE Swains.

Tribe FESTIVI Fabricius [*Danaides* Boisd.].
Danaids.

Genus **Danais** Latreille.

Danais Plexippus (Linn.). Monarch; or Milk-weed Butterfly. (Fig. 106, butterfly; figs. 67, 68, 69, 70, 71, 73, 74, 79, 107, butterfly—details; fig. 61, chrysalis; figs. 48, 78, chrysalis—details; fig. 22, caterpillar; figs. 21, 33, 39, 78, caterpillar—details; figs. 17, 18, egg.)

Tribe HELICONII Linné. Heliconians (no species mentioned.—Tropical America).

Subfamily NAJADES Borkhausen [*Nymphalinae* Bates]. Naiads or Nymphs.

Tribe ARGONAUTAE Cramer [*Apaturidae* Staud.-Wocke].

Genus **Anaea** Hübner [*Paphia* Auct., nec Fabr.].

Anaea Andria (Scudd.). Goat-weed Butterfly. (Figs. 156, 157, butterfly; fig. 97, chrysalis and caterpillar; figs. 20, 88, caterpillar—details.)

Genus **Chlorippe** Boisduval [*Apatura* Auct., nec Fabr.]. Emperors.

Chlorippe Herse (Fabr.) [*Clyton* Boisd.-LeC.]. Tawny Emperor. (Figs. 182, 183, all stages.)

Chlorippe Lycaon (Fabr.) [*Celtis* Boisd.-LeC.]. (Figs. 184, 185, all stages.)

Tribe ARCHONTES Herbst [*Limenitides* Butl.]. Sovereigns.

Genus **Basilarchia** Scudder [*Limenitis* Auct., nec Fabr.]. Purples.

Basilarchia Arthemis (Drury). Banded Purple. (Fig. 99, hibernaculum.)

Basilarchia Astyanax (Fabr.) [*Ursula* Fabr.]. Red-spotted Purple. (Fig. 40^a, spine of caterpillar.)

Basilarchia Archippus (Cram.) [*Disippus* Boisd.-LeC.]. Viceroy. (Fig. 84, butterfly; fig. 62, chrysalis; fig. 29, caterpillar; figs. 29, 40^b, 85, 86, 87, 98, caterpillar—details; figs. 2, 16, egg.)

Tribe Praefecti Herbst [*Vanessidae* Dup.].
Angle-wings.

Genus **Epicalia** Westwood (no species mentioned—South America).

Genus **Polygonia** Hübner [*Grapta* Kirby].

Polygonia interrogationis (Fabr.). Violet Tip. (Fig. 142, butterfly; fig. 181, chrysalis.)

Polygonia comma (Harr.). Orange Comma. (Fig. 83, cluster of eggs.)

Polygonia Faunus (Edw.). Green Comma. (Fig. 126, butterfly; fig. 54, chrysalis.)

Polygonia Progne (Cram.). Gray Comma. (Fig. 119, butterfly.)

Genus **Aglais** Dalman [*Vanessa* Auct. pars.].

Aglais Milberti (God.). Nettle Tortoise-shell. (Fig. 127, butterfly; fig. 82, cluster of eggs.)

Aglais urticae (Linn.). Small Tortoise-shell. (Europe.)

Genus **Papilio** Linné [*Vanessa* Auct. pars.].

Papilio Antiopa Linn. Camberwell Beauty, or Mourning Cloak. (Fig. 137, butterfly; fig. 49, chrysalis; fig. 27, caterpillar; figs. 23, 24, caterpillar—details; fig. 81, cluster of eggs.)

Genus **Hamadryas** Hübner [*Vanessa* Auct. pars.].

Hamadryas Io (Linn.). Peacock Butterfly (Europe). (Fig. 80, rudiment of wing in caterpillar.)

Genus **Vanessa** Fabricius.

Vanessa Atalanta (Linn.). Red Admiral. (Fig. 128, butterfly; fig. 72, butterfly—details; fig. 95, nest of caterpillar; fig. 13, egg.)

Vanessa Huntera (Fabr.). Painted Beauty. (Fig. 96, butterfly.)

Vanessa cardui (Linn.). Painted Lady. (Fig. 134, butterfly; fig. 179, butterfly—details; fig. 41, caterpillar—details.)

Tribe Dryades Borkhausen [*Argynnites* Blanch.]. Fritillaries.

Genus **Semnopsyche** Scudder [*Argynnis* Auct. pars.].

Semnopsyche Diana (Cram.). Diana. (Fig. 164, butterfly, scales).

Genus **Speyeria** Scudder [*Argynnis* Auct. pars.].

Speyeria Idalia (Drury). Regal Fritillary. (Fig. 158, butterfly.)

Genus **Argynnis** Fabricius.

Argynnis Cybele (Fabr.). Great Spangled Fritillary. (Fig. 162, butterfly.)

Argynnis Aphrodite (Fabr.). Silver-spot Fritillary. (Fig. 118, butterfly.)

Argynnis Atlantis Edw. Mountain Silver-spot. (Fig. 133, chrysalis.)

Genus **Brenthis** Hübner [*Argynnis* Auct. pars.].

Brenthis Bellona (Fabr.). Meadow Fritillary. (Figs. 129, 130, butterfly.)

Brenthis Myrina (Cram.). Silver-bordered Fritillary. (Fig. 131, butterfly ; fig. 132, chrysalis ; figs. 3, 9, egg.)

Tribe Hamadryades Borkh. [*Melitaeidae* Newm.]. Crescent-spots.

Genus **Euphydryas** Scudder [*Melitaea* Auct. pars.].

Euphydryas Phaeton (Drury). Baltimore. (Fig. 89, butterfly ; fig. 176, butterfly—details ; fig. 90, nest of caterpillar ; fig. 15, egg.)

Genus **Cinclidia** Hübner [*Melitaea* Auct. pars.].

Cinclidia Harrisii Scudd. Harris's Butterfly. (Fig. 47, chrysalis ; fig. 46, caterpillar—details.)

Genus **Phyciodes** Hübner.

Phyciodes Tharos (Drury). Pearl Crescent. (Figs. 140, 141, butterfly.)

Subfamily HYPATI Hübner [*Libythides* Boisd.].
(No species mentioned.) Long Beaks; or
Snout Butterflies.

Family RURALES Fabr. Gossamer-winged
Butterflies.

Subfamily VESTALES Herbst [*Erycinides* Boisd.].
Virgins; or Erycinids.

Genus **Calephelis** Grote and Robinson.

Calephelis borealis Grote-Rob. Large Metal-mark. (Fig. 187, butterfly; fig. 175, butterfly—details.)

Subfamily PLEBEII Cuvier [*Lycaenidae* Steph.].
Lycaenids.

Tribe EUMAEIDAE Doubleday (no mention).

Tribe EPHORI Herbst [*Theclides* Kirby].
Hair-streaks.

Genus **Incisalia** Minot [*Thecla* Auct. pars.].

Incisalia Niphon (Hübner). Banded Elfin. (Fig. 186, butterfly.)

Incisalia Augustus (Kirby). Brown Elfin. (Fig. 123, butterfly.)

Genus **Strymon** Hübner [*Thecla* Auct. pars.].

Strymon Titus (Fabr.) [*Mopsus* Hübn.]. Coral Hair-streak.

Genus **Erora** Scudder [*Thecla* Auct. pars.].

Erora laeta (Edw.). Spring Beauty.

Genus **Uranotes** Scudder [*Thecla* Auct. pars.].

Uranotes Melinus (Hübn.), [*humuli* Harr.; *hyperici* Boisd.-Le C.]. Gray Hair-streak, or Hop-vine Thecla. (Fig. 124, butterfly.)

Genus **Thecla** Fabricius.

Thecla Calanus (Hübn.). Banded Hair-streak. (Fig. 122, butterfly; fig. 160, butterfly—details.)

Tribe ADOLESCENTES Hübner [*Lycaenides* Kirby]. Blues.

Genus **Everes** Hübner [*Lycaena* Auct. pars.].

Everes Comyntas (God.). Tailed Blue. (Fig. 125, butterfly.)

Everes Amyntas (Fabr.). (Europe.)

Genus **Cyaniris** Dalman [*Lycaena* Auct. pars.].

Cyaniris pseudargiolus (Boisd.-LeC.) [*violacea* Edw.; *neglecta* Edw.; *Lucia* Kirby]. Spring Azure. (Figs. 148, 149, 150, 151, 152, butterfly; figs. 34, 35, caterpillar—details.)

Genus **Rusticus** Hübner [*Lycaena* Auct. pars.].

Rusticus Scudderii (Edw.). Pearl-studded Violet.

Rusticus Argus (Linn.). (Europe.).

Rusticus Aegon (W. V.) Silver-studded Blue. (Europe.)

Genus **Brephidium** Scudder [*Lycaena* Auct. pars.].

Brephidium Fea (Edw.). (Fig. 166, butterfly, scales.)

Genus **Leptotes** Scudder.

Leptotes Theonus (Lef.). (Fig. 167, butterfly, scales.)

Tribe VILLICANTES Hübner [*Polyommatides* Kirby]. Coppers.

Genus **Chrysophanus** Hübner.

Chrysophanus Thoe (Boisd.). Bronze Copper. (Fig. 117, butterfly; fig. 174, butterfly—details; fig. 12, egg.)

Genus **Heodes** Dalman [*Polyommatus* Auct. pars.].

Heodes Hypophlaeas (Boisd.) [*americana* Harr.]. American Copper. (Fig. 105, butterfly; fig. 58, chrysalis; figs. 25, 42, caterpillar; figs. 4, 7, egg.)

Genus **Feniseca** Grote (no species mentioned).

Family PAPILIONIDES Latreille.
Typical Butterflies.

Subfamily DANAI Linné [*Pierides* Boisd.].
Pierids.

Tribe FUGACIA Hübner [*Rhodoceridi* Steph.].
Red Horns; or Yellow Butterflies.

Genus **Catopsilia** Hübner [*Callidryas* Boisd. pars.].

Catopsilia Eubule (Linn.). Cloudless Sulphur.

Genus **Eurymus** Swainson [*Colias* Fabr. pars.].

Eurymus Philodice (God.). Clouded Sulphur, or Common Yellow Butterfly. (Figs. 102, 103, butterfly; fig. 56, chrysalis; fig. 52, chrysalis—details; fig. 104, caterpillar; fig. 42, caterpillar—details; figs. 5, 11, egg.)

Eurymus Eurytheme (Boisd.). Orange Sulphur.

Genus **Xanthidia** Boisduval and Le Conte.

Xanthidia Nicippe (Cram.). Black-bordered Yellow. (Fig. 66, butterfly—details; fig. 155, chrysalis.)

Tribe VORACIA Hübner [*Pieridi* Steph.].
Whites.

Genus **Pieris** Schrank.

Pieris rapae (Linn.). Imported Cabbage Butterfly. (Figs. 110, 111, butterfly; fig. 165, butterfly, scales; fig. 112, chrysalis and caterpillar.)

Pieris oleracea (Harr.). Gray-veined White. (Fig. 138, butterfly; fig. 139, chrysalis; fig. 44, caterpillar—details; fig. 10, egg.)

Genus **Pontia** Fabricius [*Pieris* Auct. pars.].

Pontia Protodice (Boisd.-Le C.). Chequered White. (Figs. 135, 136, butterfly; fig. 26, chrysalis and caterpillar.)

Pontia Daplidice (Linn.). Bath White (Europe).

Tribe FRUGALIA Hübner. Orange Tips.

Genus **Zegris** Rambur (no species mentioned—Europe).

Subfamily PARNASSII Latreille. Parnassians.

Genus **Parnassius** Latreille (no species mentioned).

Subfamily EQUITES Linné [*Papilionidae* Swains.]. Swallow-tails.

Genus **Laertias** Hübner [*Papilio* Auct. pars.].

Laertias Philenor (Linn.). Blue Swallow-tail. (Fig. 109, butterfly; fig. 75, butterfly—details; fig. 59, chrysalis; fig. 28, caterpillar.)

Genus **Euphoeades** Hübner [*Papilio* Auct. pars.].

Euphoeades Troilus (Linn.). Green-clouded Swallow-tail. (Fig. 173, butterfly—details; fig. 60, chrysalis; figs. 50, 51, 53, chrysalis—details.)

Genus **Jasoniades** Hübner [*Papilio* Auct. pars.].

Jasoniades Glaucus (Linn.) [*Turnus* Linn.]. Tiger Swallow-tail. (Fig. 153, butterfly; fig. 6, egg.)

Genus **Iphiclides** Hübner [Papilio Auct. pars.].

Iphiclides Ajax (Linn.). Zebra Swallow-tail. (Figs. 145, 146, 147, butterfly.)

Iphiclides Podalirius (Linn.). (Europe.)

Genus **Princeps** Hübner [*Papilio* Auct. pars.].

Princeps Polyxenes (Fabr.) [*Asterias* Fabr.]. Black Swallow-tail. (Fig. 190, butterfly; fig. 32, caterpillar; fig. 31, caterpillar—details.)

Family URBICOLAE Fabricius [*Hesperidae* Leach]. Skippers.

Tribe HESPERIDES Latreille. Larger Skippers.

Genus **Epargyreus** Hübner.

Epargyreus Tityrus (Fabr.). White-spotted Skipper. (Fig. 191, butterfly; figs. 65, 172, butterfly—details; fig. 180, cocoon and chrysalis; fig. 93, chrysalis; figs. 63, 64, chrysalis—details; fig. 92, caterpillar; fig. 91, nest of caterpillar.)

Genus **Thorybes** Scudder [*Eudamus* Auct. pars.].

Thorybes Pylades (Scudd.). (Fig. 188, butterfly; fig. 1, egg.)

Genus **Thanaos** Boisduval [*Nisoniades* Auct.]. Dusky-wings.

Thanaos Persius (Scudd.). Persius' Dusky-wing. (Fig. 94, nest of caterpillar.)

Thanaos Brizo (Boisd.-Le C.) Sleepy Dusky-wing. (Fig. 108, butterfly.)

Thanaos funeralis (Scudd.-Burg.). Funereal Dusky-wing. (Fig. 168, butterfly, scales.)

Thanaos Ennius (Scudd.-Burg.). Juvenal's Dusky-wing. (Figs. 77, 161, butterfly—details ; fig. 101, chrysalis ; fig. 100, caterpillar.)

Genus **Pholisora** Scudder [*Nisoniades* Auct. pars.].

Pholisora Catullus (Fabr.). Sooty Skipper. (Fig. 14, egg.)

Tribe Astyci Hübner. Smaller Skippers.

Genus **Ancyloxypha** Felder [*Heteropterus* Harr., nec Dum.].

Ancyloxypha Numitor (Fabr.) [*puer* Hübn. ; *marginatus* Harr.]. Wee Skipper. (Fig. 159, butterfly.)

Genus **Amblyscirtes** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Amblyscirtes vialis (Edw.). Roadside Skipper. (Fig. 178, butterfly—details.)

Genus **Ocytes** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Ocytes Metea (Scudd.). Cobweb Skipper. (Fig. 45, caterpillar—details.)

Genus **Atrytone** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Atrytone Zabulon (Boisd.-LeC.) [*Hobomok* Harr. ;

Pocahontas Scudd.]. Mormon. (Fig. 154, butterfly; fig. 30, caterpillar; fig. 8, egg.)

Genus **Anthomastes** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Anthomastes Leonardus (Harr.). Leonard's Hesperid. (Fig. 114, butterfly.)

Genus **Polites** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Polites Peckius (Kirby) [*Wamsutta* Harr.]. Peck's Skipper; or Yellow-spot. (Figs. 115, 116, butterfly.)

Genus **Thymelicus** Hübner [*Hedone* Scudd.; *Pamphila aut Hesperia* Auct. pars.].

Thymelicus Brettus (Boisd.-LeC.).

Thymelicus Aetna (Boisd.) [*Otho* Boisd.-LeC.; *Egeremet* Scudd.]. (Figs. 163, 170, butterfly—details.)

Genus **Limochores** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Limochores Taumas (Fabr.) [*Cernes* Boisd.-LeC.; *Ahaton* Harr.]. Tawny-edged Skipper. (Fig. 113, butterfly; fig. 169, butterfly, scales.)

Genus **Euphyes** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Euphyes Metacomet (Harr.). Immaculate Skipper. (Fig. 189, butterfly; fig. 76, butterfly—details.)

Genus **Lerema** Scudder [*Pamphila aut Hesperia* Auct. pars.].

Lerema Accius (Smith-Abb.). Clouded Skipper. (Fig. 55, chrysalis.)

Tribe CASTNIOIDES Riley. Castniarians.
(No species mentioned.)

Other figures.—72, arrangement of scales; 171, scheme to show the affinities of the groups of butterflies.

APPENDIX III.

LIST OF FOOD-PLANTS OF THE CATERPILLARS OF AMERICAN BUTTERFLIES MENTIONED IN THIS WORK.

Oeneis semidea.—*Carex rigida,* and probably other sedges.

Cercyonis Alope.—Grasses.

Satyrodes Eurydice.—Do.

Cissia Eurytus.—Do.

Danais Plexippus.—Any species of Asclepias; *Apocynum androsaemifolium.*

Anaea Andria.—*Croton capitatum.*

Chlorippe Herse.—*Celtis occidentalis.*

Chlorippe Lycaon.—Do.

Basilarchia Arthemis.—*Tilia americana, Betula lenta, Populus tremuloides,* hawthorn, willow.

Basilarchia Astyanax.—Apple, cherry, quince, hawthorn, wild gooseberry, willow, plum; *Quercus ilicifolia, Carpinus americana, Vaccineum stramineum.*

Basilarchia Archippus.—Willow, apple, different species of Populus, Prunus, *Quercus ilicifolia, Q. rubra?*

Polygonia interrogationis.—*Ulmus americana, Urtica dioica, Boehmeria cylindrica, Humulus lupulus, Tilia americana, T. pubescens, Celtis occidentalis.*

Polygonia comma.—*Humulus lupulus, Ulmus americana, Boehmeria cylindrica,* Urtica.

Polygonia Faunus.—*Salix humilis, Betula lenta.*

Polygonia Progne.—Currant, wild gooseberry, elm.

Aglais Milberti.—*Urtica dioica* and other nettles.

Papilio Antiopa.—Willows, poplars, elms.

Vanessa Atalanta.—*Urtica dioica* and other nettles, *Humulus lupulus, Boehmeria cylindrica, Parietria debilis.*

Vanessa Huntera. — *Gnaphalium polycephalum* and other species, *Antennaria plantaginifolia*, Myosotis.
Vanessa cardui.—All thistles, Helianthus, mallows, *Lappa major, Althaea rosea, Silybum Marianum.*
Semnopsyche Diana.—Viola, Vernonia.
Speyeria Idalia.—*Sericocarpus conyzoides.*
Argynnis Cybele.—Violets.
Argynnis Aphrodite.—Do.
Argynnis Atlantis.—Do.
Brenthis Bellona.—Do.
Brenthis Myrina.—Do.
Euphydryas Phaeton.—*Chelone glabra, Lonicera ciliata.*
Cinclidia Harrisii.—*Diplopappus umbellatus.*
Phyciodes Tharos.—*Aster Novae-Angliae.*
Calephelis borealis.—Unknown.
Incisalia Niphon.—*Pinus mitis, P. strobus, P. taeda, Juniperus? Lupinus perennis??*
Incisalia Augustus.—Quercus ? *Gaylussacia resinosa?*
Strymon Titus.—*Conoclinium coelestinum*, oaks, wild cherry, cultivated plum.
Erora laeta.—Unknown.
Uranotes Melinus.—*Humulus lupulus, Crataegus apiifolia, Hypericum aureum*, Phaseolus, Pinus ?
Thecla Calanus.—*Quercus rubra, Q. falcata*, Carya, Cratagus ?
Everes Comyntas.—*Lespedeza capitata, Phaseolus perennis*, Galactia.
Cyaniris pseudargiolus.—*Actinomeris squarrosa, A. helianthoides, Apios tuberosa, Erythrina herbacea, Spiraea salicifolia, Ceanothus americanus*, Cornus, Ilex ; will eat willow in confinement.
Rusticus Scudderii.—*Lupinus perennis.*
Brephidium Fea.—Unknown.
Leptotes Theonus.—Unknown.
Chrysophanus Thoe.—Polygonum.
Heodes Hypophlaeas.—*Rumex acetosella.*
Catopsilia Eubule.—*Cassia marilandica* and other Caesalpinae.

Eurymus Philodice.—Clover, garden-pea, lupine, lucerne, and other species of Medicago.

Eurymus Eurytheme.—*Astragalus caryocarpus*, Trifolium, etc.

Xanthidia Nicippe.—*Cassia obtusifolia*, *C. occidentalis*, *C. marilandica*, Trifolium, and other Leguminosae.

Pieris rapae.—Cultivated Cruciferae, especially cabbage ; also *Reseda odorata.*

Pieris oleracea.—Cultivated turnip, cabbage, and radish, especially the first.

Pontia Protodice.—Cruciferae, especially cabbage.

Laertias Philenor.—*Aristolochia serpentaria*, *A. sipho*, *Polygonum convolvulus.*

Euphoeades Troilus.—Lauraceae, particularly *Benzoin odoriferum* and *Sassafras officinale;* also *Syringa vulgaris*, *Prunus serotina*, and Zanthoxylum.

Jasoniades Glaucus.—*Liriodendron tulipifera*, *Tilia americana*, *Ptelea trifoliata*, *Prunus serotina*, *P. virginiana*, Pyrus, Crataegus, *Styrax americana*, *Fraxinus sambucifolia*, *F. platycarpa*, *Catalpa bignonioides*, *Syringa vulgaris*, *Humulus lupulus*, Carya, Quercus, *Betula alba*, *Alnus incana*, *Sassafras officinale*, Populus, Salix.

Iphiclides Ajax.—*Asimina triloba*, and other species of the genus.

Princeps Polyxenes.—Umbelliferae, particularly carrots.

Epargyreus Tityrus.—*Robinia pseudacacia*, *R. viscosa*, Wistaria.

Thorybes Pylades.—Clover.

Thanaos Persius.—*Lespedeza capitata*, *Populus balsamifera*, *Salix humilis.*

Thanaos Brizo.—*Galactia glabella*, *Cynoglossum Morisoni*, oak.

Thanaos funeralis.—Unknown, probably Leguminosae.

Thanaos Ennius.—Filbert, oak, Glycine, Lathyrus, and other Leguminosae.

Pholisora Catullus.—*Monarda punctata*, Ambrosia? *Chenopodium album.*

Ancyloxypha numitor.—*Lespedeza capitata.*
Amblyscirtes vialis.—Grasses.
Ocytes Metea.—Do.
Atrytone Zabulon.—Do.
Anthomaster Leonardus.—Do.
Polites Peckius.—Do.
Thymelicus Brettus.—Do.
Thymelicus Aetna.—Grasses, *Sabbattia gracilis.*
Limochores Taumas.—Grasses.
Euphyes Metacomet.—Do.
Lerema Accius.—Do.

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(Illustrations are indicated by heavy-faced type.)